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THE COMPLETION OF THE NEW BREAKWATER at Buffalo, N. Y., was celebrated by a dinner given under the auspices of the Buffalo Merchants' Exchange on Monday evening, Dec. 22. The dinner was held at the Iroquois Hotel and was attended by about 300 prominent citizens of Buffalo. Among the guests of honor were Major T. W. Symons, Corps of Engineers, U. S. A., under whose direction the new breakwater has been constructed, and members of his engineering staff. The responses to the toasts were made by Hon. T. E. Burton, Chairman of the House Committee on Rivers and Harbors; Major Symons, ex-Senator John Laughlin and Chas. W. Goodyear. Buffalo has now a total length of breakwater of 25,411 ft., or 4.8 miles. The total protected harbor area is 1,600 acres, of which 900 acres have a depth of over 18 ft. The work on the new breakwater was described in Engineering News of May 16, 1901, and May 29, 1902.

RUSSIAN RAILWAYS, for carrying agricultural products and promoting colonization, are being discussed by the government. Plans are now under consideration distributing the proposed extension of the Russian railway system over a period of years, and foreign loans will doubtless be called for for this purpose. The principal new lines to be constructed are—Viatka to Kief; Taschend to Orenberg, 1,080 miles; Bolagoi to Sedlets, 667 miles; Volnovokhi to Alexandroosk and Nikopol; St. Petersburg to Peinozavodsk, this last-mentioned line to be commenced in 1903.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision between a westbound express passenger train and an eastbound freight train on the Grand Trunk Ry., near Wanstead, Ont., some 20 miles east of Port Huron, Mich., on the evening of Dec. 26. Twenty-eight persons were killed outright in the wreck, and a number of the injured may possibly die. The cause of the collision was an error in the train dispatching but it is not yet clear on whom the blame rests. The operator at Watford, the station east of Wanstead, received an order for the passenger train to pass the freight at Wanstead. He claims that a few minutes later, and just before the passenger train reached Watford, the dispatcher at London, Ont., called him up and directed him to cancel the order, but gave him no substitute order as the rules require; when the passenger train came in he gave it a clearance order. He is quoted in the New York "Tribune" of Dec. 29 as saying the following:

After calling Wyoming (the station west of Wanstead) and ascertaining that the freight was there, the dispatcher called me rapidly a half dozen times. When I answered on the wire he told me to "bust" this order. I wrote "bust it" across the order just as No. 5 (the passenger train) was coming in. Conductor McAuliffe came in and asked me what the order board was out against him for. I told him that we had had an order for him, but the dispatcher had "busted" it. He asked me to hurry and write him a clearance order, which I did. After the train had started and was out of my reach the dispatcher learned that the freight had left Wyoming. I told him I could not stop No. 5, as it had left. He immediately began calling Kingscourt Junction, the station between Watford and Wanstead, on the railroad wire, and I tried to raise them on a commercial wire. We both failed to do this, however, until after the express had passed the junction.

A coroner's inquest on the victims was begun on Monday, Dec. 29, the first witness being Kerr, the dispatcher at London. His testimony is interesting in connection with the above statement of the Watford operator. It is summarized in the New York "Tribune" of Dec. 30 as follows:

Kerr sent orders to the Watford and Wyoming operators simultaneously to have the express meet the freight at Wanstead. Shortly after, Wyoming reported to the dispatcher that the freight was slow in getting out. Kerr's order was properly repeated back by both operators, and Kerr marked it "O. K." Kerr asked Wyoming why the freight was slow in getting out, Wyoming replying that he did not know. Kerr then called Watford and asked if No. 5 was coming. Watford's reply being "Yes," Kerr said, "Min may bust it." Wyoming then reported the freight pulling out. Kerr said, "Let her go." He then called the Watford operator, who reported No. 5 had gone, and that he had "busted" the order for No. 5. Kerr then called Wyoming, and told him to stop the freight. Wyoming answered, "I can't." Kerr said, "You must stop her." Kerr then called King's Court for seven or eight minutes before raising that office. King's Court reported No. 5 had passed.

The collision occurred a few minutes later, almost in front of the station at Wanstead, where the trains should have passed. At the inquest the Watford operator, Carson by name, made substantially the same statement as the one quoted above. He did not hear the word "may" preceding "bust it." He said "Bust it" was a common form of cancellation of orders.

An almost equally serious accident was a butting collision on the Colorado & Southern Ry., near Trinidad, Colo., on the evening of Dec. 24. An extra freight train, running without orders, overlooked a regular freight train which was due in the opposite direction, and collided with it when only a short distance out from its starting point. Both trains were heavily loaded. Four or five of the train men were killed, and in addition some fifteen or twenty miners who were stealing a ride on the regular train lost their lives. The exact number of the dead is not yet known.

Of the minor accidents having fatal results we note here one which occurred on another part of the Grand Trunk Ry. only a day before the Wanstead collision reported above. A heavy freight train and a helping engine sent out to meet it butted together, at Benton, near Battle Creek, Mich., when both were running at high speed. The two men of the engine crew of the helper were killed, while those of the regular train were fatally injured.

AN UPHEAVAL OF A FERRY SLIP on made land at San Francisco, occurred at the Santa Fe Railway landing. The weight of an apron leading from the shore end to the freight lighters was carried by two "caissons," 5 ft. in diameter, driven 38 ft. into the mud. Each cylinder had within it five 90-ft. piles. The newspaper descriptions are rather vague, but it seems that the unbalanced pressure of the rock being used to fill in the mud flats acted to displace the mud near the ferry slip. At any rate the cylinders with their 700-ton load were pushed laterally about 7 ft. and raised at the same time about 4 ft. The Santa Fe Railway is filling in 50 acres of land with "crushed rock" at the rate of 2,000 cu.yds. a day, at which rate the work will last a year more.

SEVERAL ELEVATED RAILWAY COLLISIONS occurred during the past few weeks on the system of the Manhattan Railway Co., in New York. No one was killed or seriously injured in any of the accidents, though a number of minor injuries resulted. Most of the accidents happened to electric trains, and are to be charged to failure of the motorman to handle the brakes properly. The old steam trains, of which a large number are still running, had vacuum brakes, while the electric trains are equipped with Westinghouse automatic brakes. The new trains, however, have higher maximum speeds. The engineers of the steam trains are given electric trains to handle as the latter are put on and replace the former. This, together with the difference in speeds and in braking equipment, causes a noticeably rough operation of trains in normal service. A midnight collision between two cars on the morning of Dec. 26, due probably to a misplaced switch, is noteworthy because the cars took fire from the third-rail and were almost destroyed. The accident occurred at a turnout, where the elevated structure covers the entire street, and the firemen had difficulty in getting at the burning cars. Service on the elevated line was tied up for over an hour by the fire.

CATTLEGUARD TESTS are being conducted by the Cattleguard Commission appointed by the Canadian government, noted in our issue of Nov. 13. A track has been arranged in one of the exhibition stables of the Central Canadian Fair Grounds, in Ottawa, and about twelve cattleguards have already been tested. The trials will be resumed on Jan. 15 and continued until all the devices submitted have been subject to test. All manufacturers and railway men are invited to submit devices and to attend the tests. We are officially informed that American manufacturers will be enabled to take in their guards and send them back free of duty. The Commission is anxious to make the tests as complete and comprehensive as possible. Information may be obtained by addressing the Cattleguard Commission of the Dominion Government, Ottawa, Ont.

THE MILLER SIGNAL system described in our issue of Dec. 18 has been installed upon 35 miles of the Chicago & Eastern Illinois R. R. (not 3.5 miles, as stated in the above article), but only six engines have so far been equipped with the signal apparatus, the system being still in the experimental stage. These six engines, however, make daily trips over the track on which the system has been installed.

THE WATER SUPPLY OF CHICAGO was reported by the Health Department to be in worse condition last week than at any time within the past ten years. This is due to the strong easterly winds which prevailed for several days, making the lake so rough that the old foul sediment on the bottom has been stirred up, so that the water is badly discolored and absolutely unfit for domestic use.

CIVIL SERVICE EXAMINATIONS for assistant civil engineer, leveler, rodman, chainman and structural engineer will be held by the New York State Civil Service Commission on Jan. 24, 1903, at Albany, N. Y. Application blanks and information regarding salaries and requirements of examination may be obtained by addressing Charles S. Fowler, Chief Examiner, Albany, N. Y.

CHANGING 22 MILES of narrow to broad gage in 24 hours was a feat accomplished Dec. 28 on the Chateaugay Railroad, by employing 600 Italians to assist all the available section men on the Saratoga and Champlain division of the Delaware & Hudson R. R., as well as those of the Chateaugay R. R. From Lyon Mountain to Saranac Lake (39 miles) narrow gage trains will still be run until spring, when that division also will be standardized.

HE WATER AND ELECTRIC POWER SYSTEM OF THE PIKE'S PEAK POWER CO., COLORADO.

By W. P. Hardesty,* C. E.

The water and electric power system to be described has other points of interest besides the technical ones. It is the first enterprise of great magnitude to take advantage of the rapid fall of the streams of water heading on the slopes of Pike's Peak, and to use them for the generation of power.

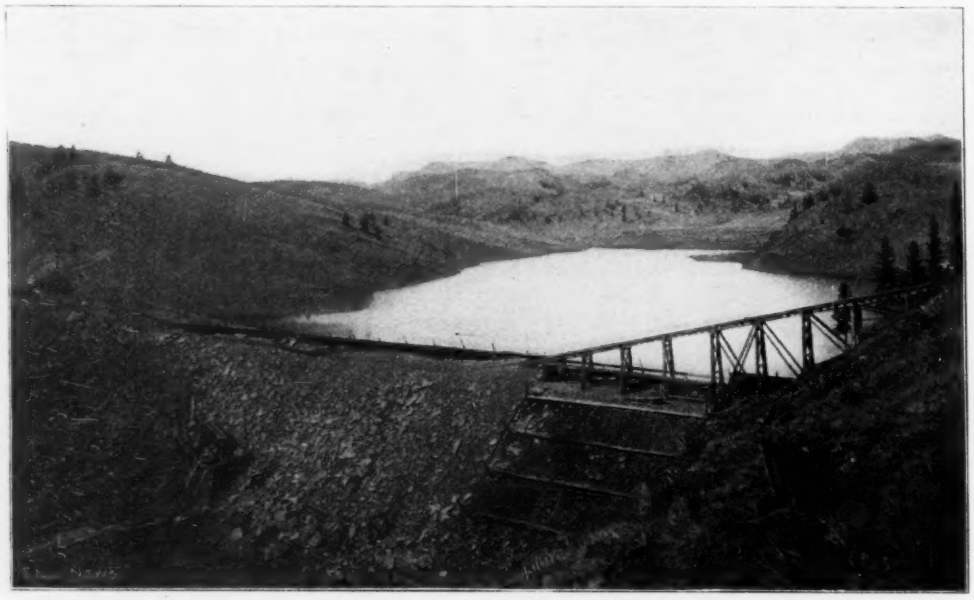


FIG. 1. STEEL-FACED ROCK-FILLED DAM, PIKE'S PEAK POWER CO., COLORADO.

(Water is being stored prior to the completion of the dam. The railway was used to bring stone from the quarry shown in Fig. 2.)

The excessive snowfall in this elevated region produces a large runoff from limited areas, which, combined with the rapid descent of the streams, presents fine possibilities in the way of water-power development. And the tremendous development that has taken place in the Cripple Creek mining district (in the immediate neighborhood) during the past ten years has created an enormous demand for power, which, moreover, can be disposed of at a high price, on account of the cost of transporting fuel into the district.†

The principal streams flowing from the south slope of Pike's Peak are the East, West and Middle forks of Beaver Creek. The Pike's Peak Power Co. was organized in 1899 to utilize the latent water power offered by these streams. During that year, the company purchased ranch property, placer claims and reservoir sites on West and East Beaver Creeks; also, located and patented placer claims along these streams, so that it now owns by patent all of the lands and reservoir sites and water-power rights on these streams for a distance of seven miles on West Beaver, 3½ miles on East Beaver and 1½ miles on the main Beaver, below the junction. These rights are in Teller and Fremont counties.

The water-power development on West Beaver (including its tributary, Middle Beaver) has already been made, and the plant has been in operation since 1901. The power station for this, known as Station A, is located on West Beaver, 2½ miles above the junction with East Beaver. This development will now be described in detail.

DAM AND RESERVOIR.—These are located 5½ miles east of the town of Victor (in and near which are located the principal mines), and about ten miles south of the summit of Pike's Peak. The reservoir has a surface area of 130 acres and holds 102,000,000 cu. ft. of water. The surface elevation, when full, is 9,081 ft. above sea level, and that of the head of the outlet pipe, 9,018 ft.

The dam (shown under construction by Figs. 1 to 3) is of the steel-faced, rock-filled type, 405 ft. long on top, 220 ft. on the bottom, 148 ft. wide at the base and 20 ft. at the top. The height from bed rock to crest of spillway is 70 ft. The up-stream face has a slope of 30° from the vertical, and the lower one of 50°. The natural foundation is a granite bed rock, which was covered by 1 to 2 ft. of soil.

The steel plates composing the face are depended on to keep the dam water-tight. They are 5 × 15 ft., the thickness for eight plates in height being ½-in., then reducing to ⅜-in., and finally to ¼-in. at the top. They are riveted together horizontally with butt straps, and vertically by 4 × 5 × ½-in. angle bars, 15 ft. c. to c., as shown by Fig. 3. The 5-in. leg of each pair of angle bars forming a joint projects into the reservoir. The angle bars are riveted together at their outer extremities, with an iron filler ⅜ × 2 ins. placed between. The expansion of the steel facing is taken up by the bending and spring in these legs, there being a distance of about 4 ins. between the plate and the filler.

The entire face was riveted up and calked as thoroughly as in boiler work, a pneumatic riveter being used. The bottom and end plates are embedded in concrete, placed in a trench cut in the bed rock. At the base is riveted a pair of 5 × 8-in. angle bars, and a foot or so above this is another pair. These are concreted around, giving an ample support for the entire face, and also serving as cut-offs for water. The ends are treated in the same way, only the angle bars are applied vertically. A space of 4 to 6 ins. next to the facing is filled with fine stone and sedimentary material, the filling being applied with enough water to pack it thoroughly.

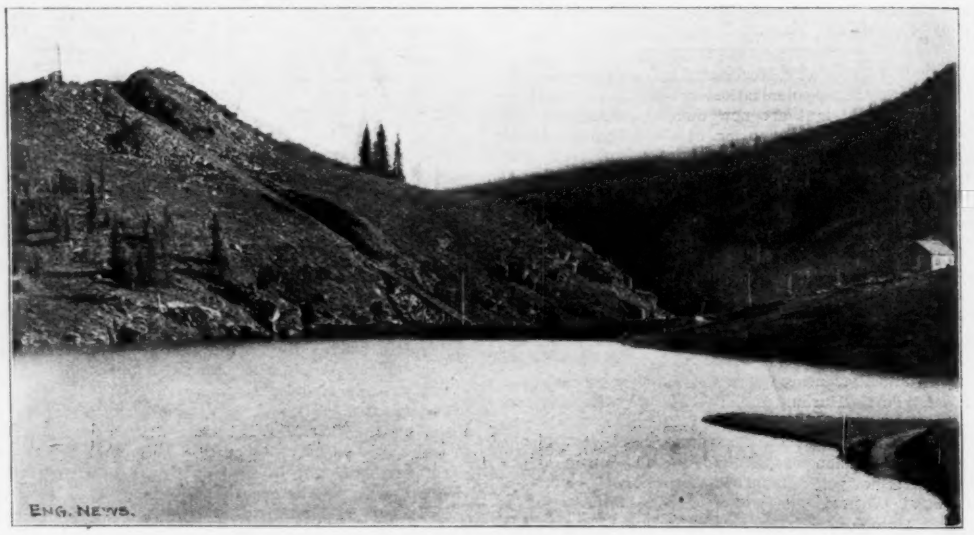


FIG. 2. THE PARTIALLY COMPLETED DAM FROM ABOVE, WITH THE QUARRY AND RAILWAY AT THE LEFT.

Next to this is the loose rock back-fill, of granite pieces of all sizes as they came from the quarry, but usually of 20 to 80 cu. ft. each. The part next to the dirt filling was laid by hand, but the remainder was dumped in. Enough small pieces resulted from the quarrying to fill the spaces between the larger ones.

Material for the body of the dam was secured from an isolated hill, called Vesuvius Butte, situated at the southeast end of the dam-site, as shown in Fig. 2. The crest of this was about 300 ft. higher than the base of the dam. A tunnel was driven into this butte at about 75 ft. below the apex, underneath which a cross-cut was made and 32,000 lbs. of black powder was exploded at one blast. This broke out two or three times the amount of rock needed.* Rock was taken from the crater thus formed without any further breaking down, except occasional small shots placed in the fissures. The broken rock was taken to the dam on a tramway with a 3-ft. gage, having a grade of 38% for the main portion of its length. Flat cars were used on this road, each weighing 11,000 lbs. empty and 38,000 lbs. loaded.

The cars were hoisted and lowered by a ⅞-in. steel cable, wound on a drum anchored on a foundation at the top of the butte. Gravity did all, a loaded car descending (retarded by brakes on the drum) and pulling an empty one up, the two passing where the tramway was double-tracked. The rock was hoisted from the crater by a derrick operated by compressed air, and loaded on to a flat box on the flat car.

During the building of the greater part of the dam, the lower part of the tramway was laid on a trestle just south of the dam. When the loaded cars reached the bottom they were detached from the ⅞-in. cable, then attached to a ⅝-in. cable and drawn up a lighter grade on the west side by a small steam hoist at the top, after which they were switched and run back down on to the dam.

Near the west end of the dam is a spillway, 50 ft. wide, cut through the granite formation. The concrete floor of the spillway is 3 ft. lower than the crest of the dam, but flash boards allow the water level to be raised to the height of the crest.

For drawing off the water from the reservoir, the 30-in. wooden stave main pipe line is continued up through the dam and extends into the reservoir for 240 ft. Where passing through the dam, it is enclosed in concrete, and in the reservoir it is supported by a rock wall, being anchored with steel cables.

A "grizzly" is made of the outer portion of this pipe in the following manner: Openings of ½-in. × 2 ft. are cut into the staves, being separated by solid strips of the same size. These 2-ft. sections are separated (longitudinally) by 6-in. sections. Only each alternate stave (lengthways) is treated in this manner, the intermediate ones being left solid. By this means, a waterway entry

*Progress Building, Salt Lake City, Utah.

†See Eng. News of Sept. 1 and Sept. 8, 1898; Dec. 19, 1901, and May 1, 1902, for description of many interesting engineering and mining features presented by this, the greatest gold camp in America.

*See Eng. News of May 17, 1900, for details of this, one of the largest blasts ever made.

30 times that which would be formed by an open end of the pipe is made, and trash and drift are prevented from entering the pipe and passing down to the wheels at the power house.

About 8 ft. lower in elevation, and over the bed of the creek, is another 30-in. pipe, which passes through the dam and about 150 ft. into the reservoir. Openings arranged the same as in the other pipe, only 3 ins. × 2 ft., are cut in the

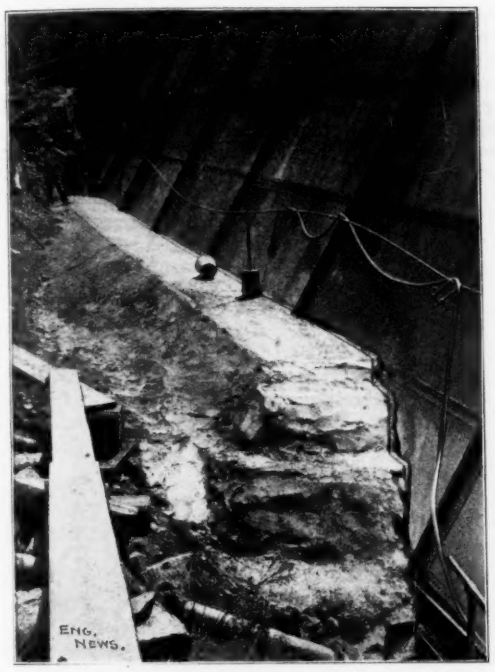


Fig. 3. View Showing Joints in Steel Plates and Concrete Foot Wall, Rock Fill and Steel Dam.

pipe for admission of water. This pipe serves as a wasteway sluice. Each of the pipes has a valve (with spur wheel gear) at the toe of the downstream slope of the dam. Each one is divided into two sections by the steel facing, being connected to the same by riveted angles.

The dam was not completed till after the rest of the system was put in operation, but was made to store a certain amount of water while building. The breaking of the storage reservoir for the Victor water-works, in May, 1901, caused a rush of water into the reservoir that swept over the partially completed dam, a rise of 8½ ft. across a width of 300 ft. taking place in ten minutes, but little damage was done.

WOOD STAVE PIPE LINE.—The conduit for carrying the water from the reservoir along the canyon side to the descent to the power house, Fig. 4, is a 30-in. wood stave pipe, 23,000 ft. long. The staves are of California redwood, milled to 1½-in. thickness, banded with ½-in. steel bands connected by cast-iron lugs. The bands are spaced, according to the pressure, from 8 to 2¼ ins. The closer spacing is used for the various inverted siphons along the line, two of which are subjected to a maximum static head of 215 ft. The hydraulic grade line from the head of the pipe is 1 in 2,000. The head of water over the pipe in the reservoir can be used to produce a much greater supply than is indicated by this grade. The pipe line follows along the westerly side of the canyon of West Beaver Creek, through a very rough country of granite formation, about one-half of it requiring cutting through solid rock. Many curves in the pipe are of only 100 ft. radius, and one has a radius of 40 ft.

A bench 6 ft. wide was excavated, and the pipe rests on this, on a bed of fine rock and dirt. This was filled in where the excavation was in solid rock. No saddles or cross-pieces are used to support the pipe, except on some of the trestles. The trestles are used on some of the dips required for crossing the side canyons without making the detour needed to head them with a supported grade. They are nearly all of hewn timber. The higher ones have piers of timber crib-work. Many have approaches formed of dry walls on the sides (battered about 4 on 1), filled in with earth and loose rock; and in some cases, where only low fills are required, these form the entire crossing. In some places the dry retaining wall is on only the lower side, all the space back of this being filled in with loose rock and dirt. Some of the trestles have a rough plank floor, laid diagonally, on which the pipe rests direct, and others have cross-pieces (spaced 6 ft.) on the stringers to support the pipe.

For hauling staves along the graded way, one-horse carts with beds about 10 ft. long (open at both ends) were used. For about two miles of the upper end of the line, the material for the pipe was hauled on a road at the bottom of the canyon, and taken upgrade at the places most accessible. Beyond this, it was delivered from above, being hauled over the high ground (fair for roads) to the edge of the canyon, and then slid down on skids.

The canyon sides become steeper and more difficult as the line follows down. At four miles from the head the grade is 700 ft. above the creek at the bottom. Here nearly vertical cliffs form a bold projection, very difficult to build around. Through this projection the "Skaguay" tunnel is run. This is 1,536 ft. long. The two end sections of the tunnel head towards each other at the start, but at about 300 ft. the north one turns about 23° to the right to follow a vein, allowing easier and quicker driving, and after following this for quite a distance, with many minor bends, the two headings again run direct to a connection. The survey of the tunnel was thus virtually a meander, as was the surface survey to connect the ends, the work thus resembling mining. Steam drills were used for driving the tunnel. No timbering was needed except right at the ends. The pipe was laid through the tunnel.

It was estimated that it would cost $70,000 more to go around the big projecting ridge here than to go through it. The pipe line would have had to dip so far down to get to practicable ground that steel pipe would be needed, and then there would be much solid rock excavation.

Just outside the lower end of the tunnel, and immediately above a 30-in. gate valve in this pipe, a 30-in. stand-pipe of wood rises vertically from the pipe line, being guyed by steel cables to the surrounding solid rock. Its top is at an elevation of 9,085 ft., being 4 ft. higher than the overflow spillway at the dam. This riser seems to prevent water ram in the pipe line, due to changes in velocity of flow. The Skaguay tunnel has an up-grade of 1.53 ft. in its length, to allow accumulations of air to escape through the standpipe.

PRESSURE PIPE AND PLANT FOR CONSTRUCTION.—From near the lower end of Skaguay tunnel, a pressure pipe leads down to the power house. This is near the bottom of the canyon, but nearly one-half mile further down the creek, so that the pipe runs diagonally down the steep slope. The country is extremely rugged, requiring some very interesting constructions.

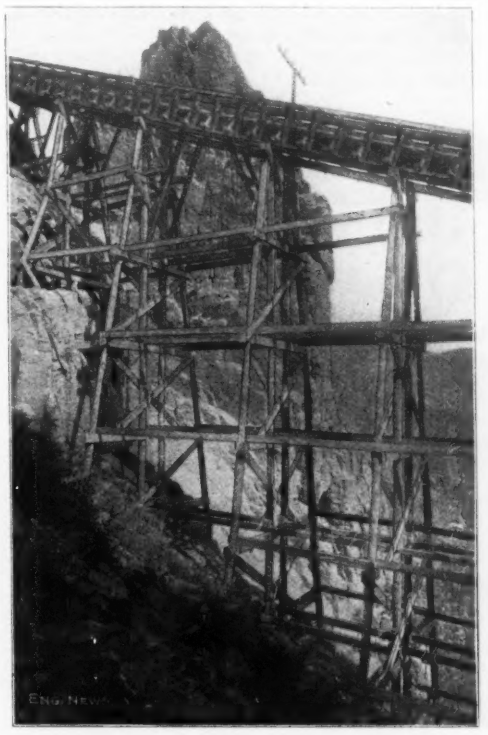


Fig. 5. View of Steel Pipe Line Carried on Railway Trestle, on 40% Grade.

These, combined with the scenic grandeur of the locality, afford some very fine views. The total length of pipe from the end of the tunnel is 3,400 ft., and there is a total fall of 1,165 ft. in 3,100 ft. horizontal distance, thus giving a static pressure of 505 lbs. For constructing this pipe line and reaching the power-house site, an inclined cable tramway was built. The upper terminus of this is at the lower end of the tunnel. Access by wagon to this locality is afforded by a flat gulch, leading from the uplands further back. All materials were hauled over this to the edge of a 70-ft. precipice, whence they were lowered by a derrick to the cars below. Here was also located a steam plant for driving the tunnel, and for operating the

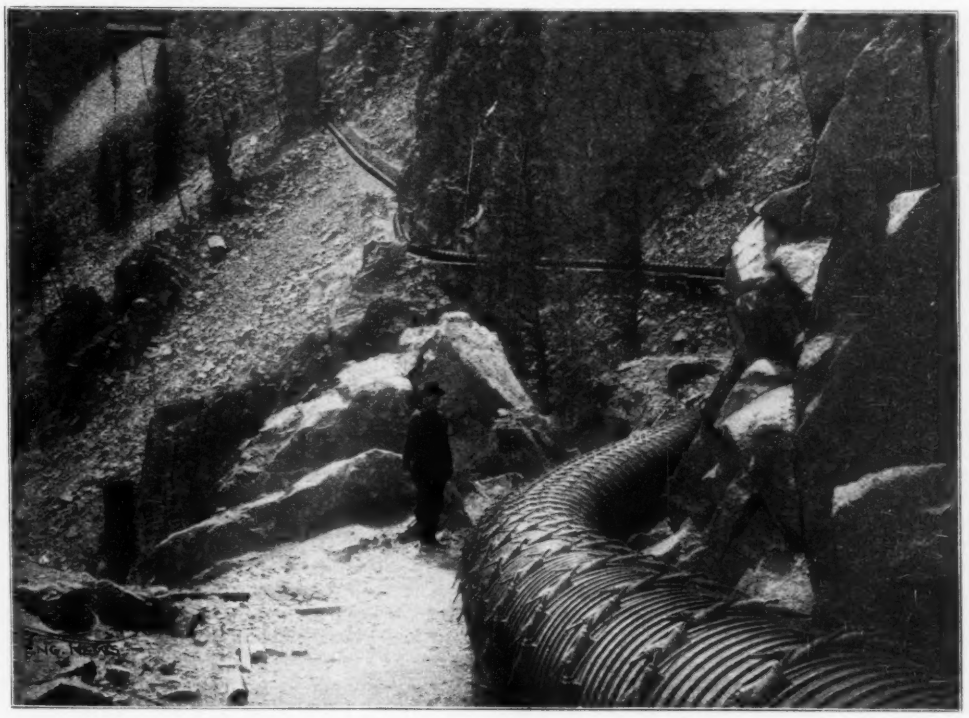
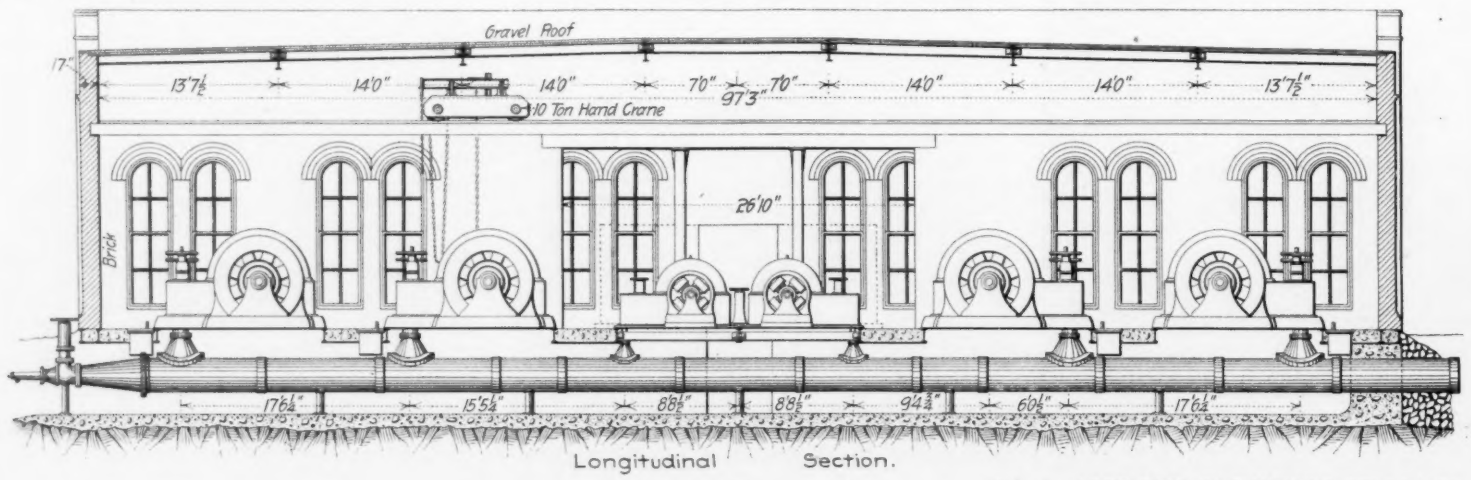


FIG. 4. 30-IN. WOOD STAVE PIPE LINE, PIKE'S PEAK POWER CO.

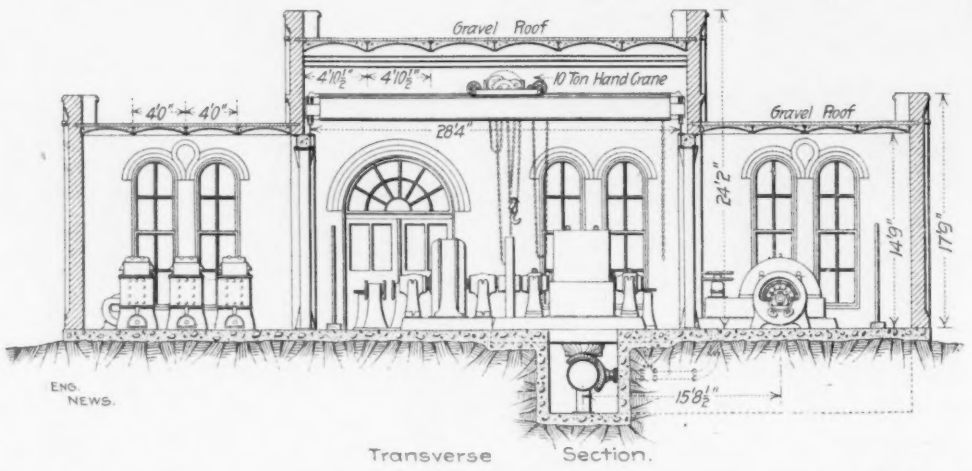
railway. Over, and near the end of, the tunnel was built a small brick house, in which was installed a double-hoist engine. This was equipped with a ¾-in. steel cable, to which the cars were attached. The descent of a load was controlled by a friction brake on the hoist. Fourteen hundred tons of building material passed down this ingenious railway. It is the only means of access to the power house.

The wood stave pipe is used to a point 300 ft. below the tunnel, where the maximum static head reaches 220 ft. From there, a 29-in. riveted steel pipe is laid, varying in thickness from ¼-in. at the head to ¾-in. near the power house. The longitudinal joints are made with butt straps, with a double row of rivets each side the seam. The circular joints are made with two rows of rivets. The sections are 6 ft. long. The receiver at the power house is made in 9-ft. sections.

For over one-half of the distance down, a line can find no natural support save that of the sides of the steep cliffs. The pipe is laid just underneath the track of the railroad all the way, the grading and special structures serving for both.



Longitudinal Section.



Transverse Section.

FIG. 6. SECTIONAL ELEVATIONS OF POWER STATION, PIKE'S PEAK POWER CO.

A view of the railway trestle, with the pipe beneath the track, is shown by Fig. 5.

The connection between the wooden and the steel pipe is concreted in, and 40 or 50 ft. below this begins a high trestle, on a 40% grade, and with a maximum height of 70 ft. On leaving this, the pipe passes through a tunnel 363 ft. in length, on a 40% grade. At other points there are extremely deep open cuts. The average grade of the pressure pipe is 38%. The steepest grade ends about 100 ft. above the power house, running 56.6% for 900 ft. Much dry retaining wall is used in places to support embankments near the foot of the steep cliffs. The lower one-quarter mile of line is on much better ground, removed from the cliffs.

The steel pipe is anchored at intervals, to prevent sliding down the steep grade. The usual anchor consists of a turn of a heavy steel cable around the pipe below a joint, each end leading up to a bolt or a short drill driven into the solid rock formation. At places thrust-anchorages of old railroad rails are used.

POWER HOUSE AND EQUIPMENT.—The power house is located on a projecting point of solid rock, which was graded off so that it gave a natural rock support for the building and machinery. It is on the west side of the creek, and 60 or 80 ft. above it. The building is 38 × 98 ft., with two side wings 16 × 48 ft. each. It is constructed of brick and steel, with concrete floor, and a corrugated steel and concrete roof covered with tar and gravel, and it is fireproof. A ten-ton hand crane runs the length of the building. Fig. 6 shows two sectional elevations and Fig. 7 an interior view of the power station.

The hydraulic equipment was manufactured by the Pelton Water-Wheel Co., of San Francisco. There are four units, each one consisting of two steel disk wheels 66 ins. in diameter, keyed to the same shaft and enclosed in the same housing. The nozzles are of the deflecting type, and work under full pressure at all times, on account of which nozzles of several different sizes are used. A 1-in. nozzle under the 1,160-ft. available head produces a net energy of 236 HP. Either wheel in a unit can be made to produce power for the full capacity of the generator connected. In operation it is customary to have the nozzles for the two wheels of different sizes, and to change them from time to time so as to work with full pressure and with slight loss of water. The regulation is of the Armstrong type, owing to the fact that automatic regulation under the conditions here would be a failure. Connections are made so that the control of the wheels of each unit is had by the station tender at a point directly in front of the switchboard panel belonging to that unit. A nozzle is used on but one wheel for medium loads, its companion wheel and nozzle being used at times as a booster, and no more than one nozzle is ever used on one wheel. As high as 610 HP. can be developed by one unit.

The receiver runs longitudinally directly under the line of wheels, and the tail-race under this. The base frames of the water-wheels and of the generators are of the same general design, and they are accurately and rigidly connected to each other by bolts and dowels. At the connection of each of the water-wheel and generator shafts is a 7-ft. flywheel, weighing 7,000 lbs. This is of cast steel, with a 3 × 7-in. rolled steel tire shrunk on. As it runs at 450 revs. per min., the periphery travels 165 ft. per sec., making such an enormous strain that a cast-iron one would probably fly to pieces. On one side the hub forms the connection to the water-wheel shaft, and on the other side the coupling is formed by one-half of the hub section being keyed to one-half of the generator shaft. The water-wheels develop an efficiency of about 83%. The full station capacity requires a supply of 18 sec.-ft. of water.

The electrical generators now in operation are four 400-KW. General Electric machines, 3-phase, 30-cycle, with stationary armatures and rotary fields, working at 600 volts pressure, and making 450 revs. per min. Two 4-pole exciters, direct-current, 30-KW. machines, running at 675 revs., produce an exciting current at 70 volts. Each can supply all four generators working at full load. The generators develop an efficiency of about 94%. In the northeast wing of the building are six 250-KW. transformers of the General Electric make, having 600 volts on the primary side and 12,600 on the secondary. They are cooled by an air blast from a fan driven by a small Pelton wheel. There are twelve single-pole General Electric lightning arresters.

The switchboard apparatus is especially elaborate and convenient. There is one exciting current panel, four generator panels, two distributing panels, two high-tension panels, and one synchronizing panel. Each panel is of Vermont marble, 62 × 36 ins., with a sub-base of 28 × 36 ins., and with a complete equipment of all needful apparatus. The cable connections between the generators, switchboard and transformers are all highly insulated, and laid in conduits in the concrete floor. The main line switches from each generator are operated independently, either for power or light. The circuits are arranged so that any or all of the machines may be applied on either circuit.

Since putting the station in operation, it has been found necessary to secure some thorough system for combined arc and incandescent lighting, which has been accomplished by installing two 200-KW., compensated, 3-phase, 60-cycle generators with full equipment. These are 12-pole generators, and run at 600 revs. Each contains its own independent, direct-current, 12-pole exciter, built directly on the revolving field shaft. These generators are also driven by impulse type water-wheels, to which they are directly connected. They are located in the southwest wing of the building.

TRANSMISSION AND DISTRIBUTION.—The transmission line from Station A to the sub-station, at the Gold Coin Mine at Victor, is eight miles long. There are two circuits of three wires each. The power circuit is of three No. 4 B. & S. copper wires, and the lighting circuit of three No. 6 wires. These can deliver 1,600 KW. with a loss of less than 5%, with a voltage of 12,600 on both the 30-cycle and 60-cycle lines. The wires are transposed at intervals of one-half mile. The poles also carry two telephone wires, transposed every 120 ft. The porcelain insulators are 5½ ins. in diameter, and each is made of three independent cups. In manufacture they were subjected to a 40,000-volt salt test. The poles are of

Idaho cedar, 8 to 10 ins. in diameter at the top, 30, 35 and 40 ft. long in the country and 50 ft. in Victor, spaced 120 ft. c. to c.

The substation is a fireproof structure of brick, concrete and steel. Here most of the current is transformed through nine General Electric 50-KW. oil transformers, with 12,000 volts on the primary side, and 115 and 460 on the secondary side for local lighting and local power work. There is also a set of three 50-KW. oil transformers, 12,000 × 350 volts, which operates a 120-KW. rotary converter, which in turn operates a locomotive for hauling in a mine tunnel.

High pressure (primary) distributing lines leave the substation in various directions (after first passing through 20,000-volt oil switches), reaching a number of mines, mills and towns in the neighborhood, where both power and lighting are distributed.

PROJECTED DEVELOPMENTS OF WATER POWER.

Important enlargements of the power system are contemplated. The water from the tail-race at Station A is to be carried in a pipe resting on a bridge across to the east side of West Beaver Creek and up to a grade level, where it will unite with the water brought from the creek through a small pipe that will tap the creek at about 800 ft. above here. There is a cumulative flow of considerable amount that arises between here and the dam, and it can be used in this manner. From here a pipe line will extend about 2¾ miles to Station B, at the junction of West and East Beaver Creeks. The head attainable here is 1,257 ft.

Station B will also be supplied by a small pipe line leading up East Beaver to the same static level as the tail-race of Station A. It is expected that the water from this branch will be sufficient to develop 2,000-HP., and that from the West Beaver, 3,500 HP.

Water from the tail-race of Station B, and also the accumulations gathered from the two branches (all amounting now to about three times that for Station A) is to be carried on down the canyon side of the main Beaver Creek, and a drop of 492 ft. secured for Station C. This is about two miles below Station B, and near the mouth of the canyon.

The company also owns a good reservoir site on East Beaver Creek, in elevation 1,700 ft. above Station B, and only 2½ miles distant from it, which may be developed to excellent advantage.

It is the intention to construct an independent transmission line from Station B to Station A, and possibly an independent line from Station B to the sub-station at Victor, which, including the connections through Station A, will allow the use of the entire energy of both stations to work in parallel over either station's lines.

The entire system so far constructed has been built entirely by day labor, and no pains nor expense have been spared to have all work done in the most perfect manner possible. The engineering and construction were carried out by Mr. R. M. Jones, Engineer and General Superintendent. Mr. Jones is the engineer who built the Big Cottonwood power plant, and the Jordan Narrows power plant, both near Salt Lake City, Utah. The total cost of the system, including land, water rights and secondary distribution, has been over $750,000.

The Pike's Peak power Co. is one of the branches of the Woods Investment Co., of Colorado Springs, Colo. This company carries on its many enterprises in the Cripple Creek district through a number of mining and industrial incorporations. The officers are: Warren Woods, President; H. E. Woods, Vice-President and Treasurer; and F. M. Woods, Secretary and General Manager. The general offices of the Pike's Peak Power Co. are located at Victor, Colo.

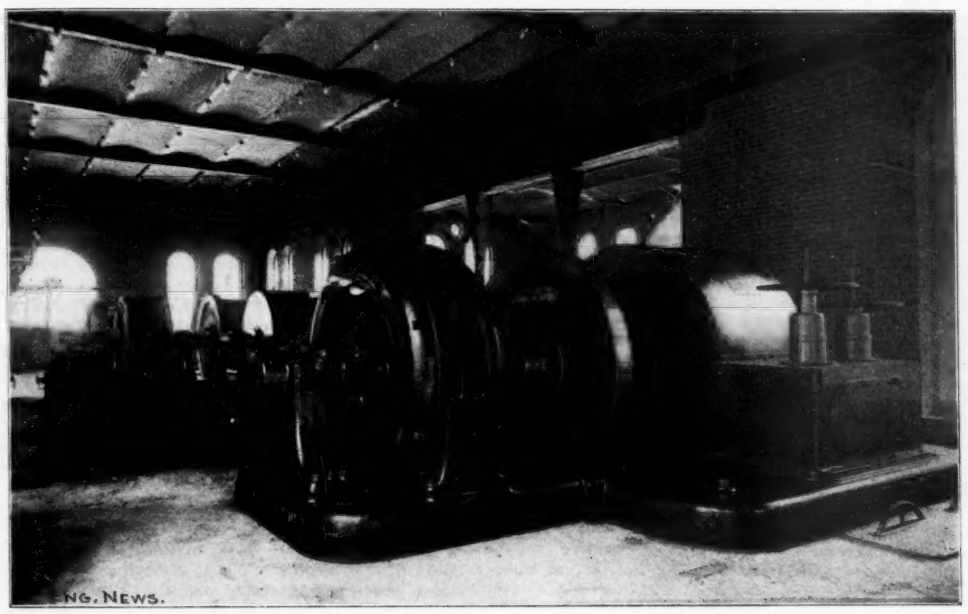


FIG. 7. INTERIOR VIEW OF STATION OF PIKE'S PEAK POWER CO., BEFORE ALL MACHINERY WAS PLACED.

MODERN TENDENCIES IN THE DEVELOPMENT AND TRANSMISSION OF POWER.*

By John Joseph Flather, M. Am. Soc. M. E.

It has been stated that to the construction and perfection of her machinery, more than to any other cause, may be ascribed the present commercial supremacy of the United States. Be that as it may, the economical production of her manufactures and the convenient adaptations of time and labor-saving devices in all the various lines of constructional work have certainly exerted a wonderful influence in the upbuilding of her industries.

Among other significant features the present tendency in the development and use of this class of machinery is marked by the adaptation of compressed air and the application of electric power to machine driving.

The labor cost in most machine shops and other works is so much greater than the cost of power, that any expedient by which the labor cost may be appreciably reduced is justified, even though the efficiency of the agent itself be low. Whenever new methods or agencies cause an increased production with a given outlay for labor, we shall find these methods superseding the old, even though the cost of the power required be greater than before. The saving of power is a consideration secondary to the advantages and economical output obtained by its use.

While economy in the use of power should therefore be secondary to increased output, yet careful attention to details will often greatly reduce the useless waste of power.

COMPARISON OF SHAFTING AND INDEPENDENT MOTORS.

Engineers have recognized for some time past that there is a very great percentage of loss due to shaft friction, which, in railroad and other shops, where the buildings are more or less scattered, may be as great as 75% of the total power used. In two cases known to the speaker these losses are 80 and 93% respectively. In the ordinary machine shop this loss will probably average from 40 to 50%. No matter how well a long line of shafting may have been erected, it soon loses its alinement and the power necessary to rotate it is increased.

Manufacturers are realizing the loss of power which ensues from the present system of transmission, and we find a general tendency to introduce different methods by which a part of this loss will be obviated. Among these are the introduction of hollow and lighter shafting; higher speeds and lighter pulleys; roller bearings in shaft hangers; and the total or partial elimination of the shafting.

Indepedent motors are often employed to drive sections of shafting and isolated machines, and among these we find steam and gas engines, electric motors, compressed air and hydraulic motors, although the latter have not been used for this purpose to any great extent in this country.

It was only a comparatively few years ago when the large and economical Corliss engines were replaced at the Baldwin Locomotive Works by a greater number of small, simple expansion engines, which actually required about 15% more steam per horse-power hour than the Corliss engines. This loss, however, was only apparent, for by increasing the number of units and locating them at convenient centers of distribution much of the shafting and belting could be dispensed with and an actual saving was obtained. Later, these simple engines were replaced by a number of compounds, some 18 being in service; subsequent tests on these showed a saving of 30% over that obtained by the use of the simple engines.

More recently, however, the electric motor has superseded the steam engine for this work, as its economy and convenience over the latter is now thoroughly recognized.

ELECTRIC POWER DISTRIBUTION IN SHOPS.

A considerable difference of opinion exists as to whether individual motors should be used with each machine, or whether a number of machines should be arranged in a group and driven from a short line shaft. There are well-defined conditions to which each system is best adapted, but there are wide limits between which there appears to be no general rule and we find both methods occupying the same field.

For isolated machines and for heavy machines that may be in occasional use the individual motor is particularly well adapted, as it consumes power only when in operation. It is, however, necessary that each motor thus connected shall be capable of supplying sufficient power to operate its machine under the heaviest as well as lightest loads. In certain cases, moreover, the load is liable to vary great irregularity, as, for instance, in metal-working planers, in which the resistance offered by the machine at the moment of reversal of the platen is far higher than at other times, and may be so great as to endanger the armature of the motor. Under these conditions it is necessary to use a motor of much larger capacity than the average load would indicate.

Ordinarily in machine-driving the motor is shunt-wound, and the current through the field-coils is constant under all conditions of load; but to obtain the best results with this class of machinery, in which the load is intermittant and subject to sudden variations, the motor should be compound-wound so as to increase the torque without an excessive increase of current in the armature.

In many cases with individual motors, owing to wide variations in power required, the average efficiency of the motor may be very low; for this reason a careful consideration of the conditions governing each case indicates that for ordinary machine-driving, especially with small machines, short lengths of light shafting may be frequently employed to good advantage and the various machines, arranged in groups, may be driven from one motor. By this method fewer motors are required and each may be so proportioned to the average load that it may run most of the time at its maximum efficiency.

In arranging such a system of power distribution the average power required to drive is of as much importance as the maximum, for in a properly arranged group system the motor capacity need not be the equivalent of the total maximum power required to operate the several machines in the group, but may be taken at some value less than the total, depending upon the number of the machines and the average period of operation. On the other hand, as already shown, the motor capacity of independently-driven machines must not only equal the maximum power required to drive the machine at full load, but it must be capable of exerting a greatly increased momentary torque. In any case large units should be avoided, for the multiplication of machines driven from one motor entails additional shafting, countershafts, and belting which may readily cause the transmission losses to be greater than that obtained with engines and shafting alone, besides frustrating some of the principal objects of this method of transmission.

As far as the efficiency of transmission is concerned it is doubtful whether in a large number of cases motor-driving per se is any more efficient than well-arranged engines and shafting.

As already pointed out, the principal thing to be kept in mind is a desired increase in efficiency of the shop plant in turning out product, with a reduction in the time and

*Slightly condensed from the Vice-Presidential address before Section D (Engineering and Mechanical Science), delivered at the Washington meeting of the American Association for the Advancement of Science, Dec. 29, 1902.

labor items, without especial reference to the fuel items involved in the power production.

On account of the subdivision of power, which results from the use of many motors, there is less liability of interruption to manufacture, and in case of overtime, it is not necessary to operate the whole works, with its usual heavy load of transmitting machinery.

Another advantage is the adaptability to changes and extension; new motors may always be added without effecting any already in operation, and the ease with which this system lends itself to varying the speed of different unit groups is a very potent factor in its favor.

SPEED VARIATION WITH ELECTRIC MOTORS.

One serious obstacle to the use of connected motors with machine tools is the difficulty of obtaining speed variation which is so necessary with a large proportion of the machines in common use. A certain amount of variation can be obtained by using a single voltage system with shunt field regulation, but the variation in this case is very limited. This, however, may be increased by using a double commutator if space will permit.

The 3-wire 220-volt system offers many advantages both for power and lighting systems and is very frequently employed. Variations of speed may be obtained with this system by using a combination of field regulation with either voltage, and, in rarer cases, the use of a double-commutator motor.

A method which has been used recently with considerable satisfaction involves the use of a 3-wire generator with collector rings connected to armature winding, similar to that of a 2-phase rotary converter. Balancing coils are used and the middle points of these are connected to the third wire, which is thus maintained at a voltage half way between the outer wires. This system is simple and economical and possesses all the advantages of the ordinary 3-wire method, which permits similar variations in speed by field regulations with either voltage; and if still wider ranges are desired a double commutator motor may be used.

In other recent installations the 4-wire multiple voltage system is used which permits of very wide variations of speed in the operation of the tool. This system gives excellent results and removes one of the objections urged against direct-connected motor driven tools, namely, that such machines are not sufficiently flexible in regard to speed variation, and that such variation can only be obtained by throwing in resistances which cut down the efficiency of the motor, or by varying the strength of field which reduces the torque.

The multiplte voltage system, however, has some serious disadvantages. It cannot usually be operated from an outside source of power without rotary transformers; the generating sets and switchboard are complicated and the total cost of installation is expensive; yet with these drawbacks the system is growing in favor, as it has manifest advantages which outweigh the objections.

The storage battery has been used to some extent to obtain multiple control and is suggestive of interesting possibilities, but in its present form it is not altogether desirable for machine tools.

In many of the larger sizes of certain metal-cutting machines it is probable that marked changes will be produced in the immediate future and the indications are that direct-connected motors with wide variations of speed and power will be incorporated in the new designs.

The recent improvements in the manufacture of certain grades of tool steel have shown indisputably that the present designs of machine tools are not sufficiently heavy to stand up to the work in order to obtain the economy of operation which results from the use of such steels. Higher speeds, heavier cuts and greater feeds may be obtained if the machines will stand the strain, but in most cases the capacity of the machine is not commensurate with the ability of the tool to remove metal. With cutting speeds of 100 to 200 ft. per minute, it is evident that the power requirements will be much greater than the ordinary machines of to-day which have a cutting speed of from 10 to 30 ft. per minute. As an illustration of what can be done with these new tool steels the speaker was recently shown some steel locomotive driving wheels which had been turned up in 2 hrs. and 40 mins., whereas the regular time formerly required was not less than 8 hrs. In this case even better results could have been obtained, but the belts would not carry the load.

Here, then, we find an interesting field for the direct-connected motor with ample power and speed variation for any work which it may be called upon to perform.

While the preference is easily given to continuous-current motors for the purposes of machine driving, yet we find alternating-current motors used to a considerable extent, the proportion of motors in service being about 1 to 5 in favor of the continuous-current motor. Both synchronous and induction motors are employed, but the advantages possessed by the latter case this type to be preferred, although in long-distance transmission, both types should be used in order to obtain satisfactory regulation. As shown by Mr. H. S. Meyer,* the induction motor can readily be worked at variable speeds, which is accomplished in three different ways: First by rheostatic control, which is decidedly the cheapest and easiest method to manipulate. Second, by varying the impressed voltage, which, however, necessitates the use of a transformer or compensator with variable ratio; this is very inefficient at the lower speeds and can only be used under certain conditions, and third, by altering the number of poles, which is mechanically very complicated, but where the speed cariation is only one-half or one-quarter it may be used efficiently.

One serious disadvantage met with in all induction motors is the lag produced by the self-excitation and self-induction, and its reaction on the circuit. This lag is particularly unsatisfactory with intermittent service, such as machine driving, where the motors have to run under light and variable loads; in such cases the power factor is probably not over 60 or 70%.

*London "Engineering," April 19, 1901.

EFFICIENCY OF ELECTRIC POWER TRANSMISSION.

It may be interesting to note the efficiency of electric power. A modern shop generator belted from an engine will have an efficiency of about 90% when working under favorable conditions, but as the average load is ordinarily not more than two-thirds full load, and often much less, the efficiency will not usually be more than 85%. Since the engine friction was added to the losses in compression, so also it should be considered here, in which case the efficiency of generation will lie between 75% and 80%. With a 3-wire, 220-volt system, which is very suitable for ordinary shop transmission when both light and power are to be taken off the same dynamo, the loss in transmission need not be more than 5%, so that the efficiency at the motor terminals will not be far from 75%. With motors running under a nearly constant full load the efficiency of motor may be 90%; but with fluctuating loads this may fall to 60% at quarter load. In numerous tests made by the speaker the average load on several motors in machine shops has been only about one-third of the rated capacity of the motor. It is interesting to note that in tests made at the Baldwin Locomotive Works it was found that with a total motor capacity aggregating 200 HP., a generator of only 75 KW. was sufficient to furnish the current, and ordinarily only 60 KW., or 40%, was required. At the present time there are in use at these works upwards of 300 motors, with a combined total capacity of 2,200 or 2,300 HP., whereas the generator output is only about 500 KW.

Under these conditions, when the driven machines are not greatly over-motored, we may assume a motor efficiency of 80%, which may be less or greater in individual cases. The combined efficiency, then, of generator and motor working intermittently with fluctuating loads will be about 60% of the power delivered to the engine.

For greater distances than those which obtain in plants of this character the loss in transmission will be greater, and higher voltage must be employed in order to keep down the line loss. While it is possible to put in conductors sufficiently large to carry the current with any assumed loss, yet the cost of the line becomes prohibitive with low voltage.

Where cheap fuel is available it is found in most cases that electric power can be generated at the works more cheaply than it can be purchased from a central station; especially is this the case if the exhaust steam be used for heating purposes. In isolated plants the cost of transmission is very small as compared with the total cost of generation; whereas in the average central station the cost of transmission, which includes interest and depreciation on the pole line, usually constitutes a large percentage of the operating cost.

In those localities where the cost of fuel is high, electric power can often be purchased more cheaply from a central station which obtains its power many miles distant and transmits it electrically to a convenient distributing center where it is used for power and light.

The recent development in electrical transmission is very marked, and one constantly hears of some new achievement more wonderful than anything previously accomplished. Distances have been gradually increased until it is now possible to transmit electrical energy economically and in commercial quantities for distances up to 150 and even 200 miles.

There has been a steadily increasing tendency to raise the line voltage in such transmissions and to-day we find in successful operation voltages as high as 40,000 and even 60,000, as compared with the 4,000 and 6,000 volts of a few years ago.

As pointed out by Mr. A. D. Adams,* so far as present practice is concerned, the limit of use of high voltage must be sought beyond the transformers and outside of generating and receiving stations. As now constructed, the line is that part of the system where a final limit to the use of higher voltage will first be reached.

In order to avoid the temporary arcing and leakage between the several wires it is necessary to place the wires a considerable distance apart, which, with higher voltages, may lead to a modification in construction of pole line. The plan of substituting a series of steel towers about 90 ft. in height and 1,000 ft. apart is being seriously contemplated.†

In this case it is proposed to suspend the wires from tower to tower and separate them about 9 ft. apart. While expensive in first cost it is thought that the satisfactory working of the system and freedom from breakdown with the low maintenance and depreciation charges involved, would warrant the investment.

A more seriously difficulty is found in the insulator, which is generally looked upon with distrust for the higher voltages in use to-day. With a more perfect insulator there would appear to be no good reason why the present maximum voltages should not be exceeded.

*Eng. Mag., October, 1902.

†Geo. H. Lukes. in Trans. Assn. Edison Illuminating Companies, July, 1902.

POWER DEVELOPMENT WITH GAS ENGINES.

The possibility of electrical transmisison thus permits of the utilization of available sources of power at great distances from the center of distribution; but while it is interesting to know that a certain amount of power may be transmitted a given distance with a high degree of efficiency, it is more important to know whether the same amount of power could be obtained at the objective point more economically by other means.

One interesting phase of the power problem which forcibly presents itself to the engineer at the present time is the vast possibilities possessed by the modern combustion engine, which includes the various types of gas and oil engines. While its use as a motor in industrial establishments has been somewhat limited, yet there is a marked tendency to employ the gas engine in manufacturing works, and a consideration of its advantages and cost of operation, together with its high thermal efficiency and possibility of still further improvement, indicates that for a great many purposes both steam engines and electric motors may be ultimately replaced by gas engines.

While the first cost of electric motors in the smaller sizes is considerably less than the cost of well-made gas engines for similar capacities, the saving during the first six months of service, due to the more economical operation of the gas engine, will often more than compensate for the difference in first cost.

That the gas engine in both large and small sizes has reached a point in its development where it can fairly rival the steam engine in reliability and satisfactory running qualities there can be no question. In point of fuel economy, a gas engine of moderate size is on a parity with the largest triple-expansion steam engine, and will give a horse-power on less than 1 lb. of fuel.

The high price of gas in this country has contributed largely to those causes which have prevented a more common use of the gas engine as a motor. For this reason the gas engine has generally been used, not so much because of its high efficiency as a thermodynamic machine, but rather on account of its convenience and saving in labor. It is true that natural gas is cheap, but it is equally true that natural gas is not generally available.

It is to producer gas that we must look for any marked increase in the use of the gas engine. Fortunately the manufacture of producer gas has reached a high state of development and there are now in successful use several processes by which power gas can be made from cheap bituminous coals as well as anthracite and coke. The leanness of such gases renders them less effective per cubic foot of gas, as compared with the richer coal gas or even water gas; but this difference is more than compensated for by the low cost of production. It is upon such power gas that the commercial future of the gas engine as a general motor depends.

A prominent factor in gas-engine practice which has attained a high degree of development in European practice, is the small gas producer. These generators are very simple in operation and furnish a convenient and economical means of obtaining power at a much lower rate than with the ordinary city lighting gas. Generally small anthracite coal or coke is used, but several methods employ bituminous coal, lignites, or wood. With bituminous coal, means must be provided for removing the tar and ammonia and other products of distillation.

The process of generation in some of the more recent producers is entirely automatic and depends upon the demand of the engine, so that no storage capacity is required. The economy of these small producers is shown by tests which give 1 HP. on a 16-HP. engine with a consumption of only 1.1 lb. of fuel. For engines above 40 HP., 1 HP. can be obtained on ⅞-lb. of fuel.

The gas engine industry received a signal impetus when it was discovered that blast-furnace gases could be readily utilized direct in combustion engine without the intervention of boilers and without any special purifying processes. A still more important circumstance which is far reaching in its results is the fact shown by Professor Hubert, of the Liege School of Mines, that the superior economy of the gas engine enables equal power to be obtained with 20% less consumption of furnace gas than was formerly used in the generation of steam.

The successful employment of large combustion engines in this way utilizes vast sources of power which a few years ago were allowed to go to waste or at most were used very inefficiently.

The high thermal efficiency of the gas engine has long been recognized and the possibility of further development is a promising factor in this field. The already accomplished efficiency of 38%, reported by Professor Meyer, of Goetingen, greatly exceeds the maximum theoretical efficiency of the steam engine and more than doubles its

actual best obtainable working efficiency, but the end is not yet.

With higher compression even greater efficiencies may be expected. But with high compression there is danger of premature explosion due to the generation of heat in compressing the gas in the presence of oxygen; for this reason Herr Diesel compresses the air separately. Under a pressure of 500 lbs., or more, which is used in the Diesel motors, the air becomes very hot and readily ignites a charge of liquid fuel which is injected into the compression chamber. There is no explosion; combustion occurs while expansion goes on and the heat generated disappears in the form of work.

Efficiencies of 30% or more have been obtained with blast-furnace gases which contain a very small percentage of hydrogen, and this with the high rates of compression which can be carried has led to the advocacy of non-hydrogenous mixtures in large engines. Certainly very high rates of compression may be had with a non-hydrogenous producer gas without fear of premature ignition, and it has the additional advantage of economical production.

The practice of making the cylinder in combustion engines act alternately, first as air compressor then as motor, has the advantage of greater simplicity, but it means immensely larger engines for the same power, since the number of effective impulses is thus cut in two.

The danger of pre-ignition and consequent severe shock on the engine also necessitates very heavy construction in the smaller engines in order to obtain a reasonable degree of safety in operation. Moreover, the smoothness of action is greatly retarded with this form of engines, especially if the governing is controlled by the "hit and miss" method, in which the regulation is effected by varying the frequency of the explosions, thus causing great variations in the driving torque.

Various expedients have been employed to overcome these defects, such as the use of multi-cylinders and different methods of control, but the size and cost of engine has been increased rather than decreased. Notwithstanding these well-recognized defects in the 4-cycle type of engine, it constitutes by far the largest class in use to-day of what may be called successful gas engines.

More recently very satisfactory results have been obtained in the construction of 2-cycle engines. In some of these we find separate pumps employed to compress the charge of gas and air, which ignites and burns as it enters the cylinder. Higher compression is thus obtained without fear of pre-ignition, and this permits smaller clearance spaces with attendant advantages.

If the engine is single acting, an impulse is obtained every revolution, which thus insures better speed regulation, as well as double the power for a given sized cylinder.

The highest thermal efficiency yet attained, namely 38%, has been secured with a 2-cycle type of engine which compresses the air and gas in separate pumps to a nominal pressure of 8 or 10 lbs.; the air under this pressure being used to scavenge the cylinder toward the end of expansion. After the unconsumed products of combustion have been forced out by the fresh air, the cylinder walls having been cooled thereby, a charge of gas is admitted and compressed to a pressure of 150 to 175 lbs.; and then exploded, as in the usual method. This engine is double acting and receives a charge each side of the piston; thus two impulses are received each revolution, in a manner precisely similar to that of a steam engine.

Whether these engines will be as satisfactory for small motors remains to be seen. It is possible that the greater complication of details in the two-cycle types as compared with the simpler 4-cycle engine will cause the latter to continue to give the greater satisfaction, at least for the smaller sizes.

At the last meeting of the British Association, Mr. H. A. Humphrey gave some interesting data concerning recent gas engines, and the record is both remarkable and significant. The limiting size has rapidly grown during the past two years, as shown by the fact that one manufacturer is now constructing a gas engine of 2,500 HP., and is prepared to build up to 5,000 HP.

In August, of this year (1902), two leading English manufacturers had delivered or had under construction over 50 gas engines varying in size between 200 and 1,000 HP.; but we have to look across the Channel for still greater achievements in this direction.

Neglecting all engines below 200 HP., we note that a classified list of gas engines in use or under construction shows the remarkable total of 327 gas engines capable of supplying 182,000 HP. This gives an average of about 560 HP. per engine.

Although this country has lagged somewhat behind Europe in adopting large gas engines, there is evidence that this state of affairs will not exist very long, for a number of enterprising firms are already in the field prepared to build gas engines up to any required size. One firm has already sold over 40,000 HP. of large engines, most of them of 2,000 HP. and several of 1,000 HP. for coupling to electrical generators. Another firm has recently built two 4,000-HP. gas compressors and also a number of 1,000-HP. gas engines.

It is not to be presumed that the gas engine will displace either the electric motor or the steam engine; each has its legitimate sphere of usefulness, and each will be more highly developed as the result of direct competition. Yet the economies already obtained indicate that the field of the gas engine will be extended more and more into that of the steam engine and electric motor.

IMPROVEMENTS IN STEAM MOTORS.

Many of the questions involved in this consideration are at the present time in a transitional stage. The reciprocating steam engine has reached a high state of development, but it is not probable that it has attained its highest degree of perfection. While an economy less than 9½ lbs. of steam per horse-power hour has been obtained, even better results may be anticipated; the use of high-pressure superheated steam in compound, jacketed engines involves more perfect lubrication and this may demand modification in existing valve types; however this may be, the outlook is promising for still higher efficiencies. Especially with intermittent or variable loads, however, it is not so much a question of maximum efficiency as it is economy of operation.

From this point of view the present activity in the construction and development of the steam turbine is of interest to engineers and power users. The steam consumption of a modern steam turbine of moderate size compares very favorably with that of the better class of large reciprocating engines, but what is of greater importance is the evident superior steam economy under variable loads. The steam consumption per horse-power varies little from one-third to full load; at overloads the economy, as shown by numerous tests, may be even better.

This feature predestines the steam turbine to the special field of electric lighting and power generation, where it must inevitably become a formidable rival of the larger-sized, slow-speed, reciprocating steam engine.

It is a significant fact that immediately following upon the installation of the large 8,000-HP. compound steam engines at the central station of the Manhattan Elevated Railway, New York, we find three 5,000-HP. steam turbines under construction for the Rapid Transit Railway there.

The high rotative speed of the steam turbine is a prominent factor in favor of its adoption in connection with electrical generators, since the cost of the generator end of the equipment ought eventually to be very materially reduced; but for many lines of work the high rotative speed of the present types of steam turbine is prohibitive, nor can it be adapted successfully to belt driving. However, it is fair to presume that the present limitations of the steam turbine are not insuperable, and that the attention which is now being given to its development will evolve a more universal type of motor adapted to general power purposes with large and small units alike.

THE 64TH ST. SEWER TUNNEL AND OUTLET SEWER, BROOKLYN, N. Y.

To drain the Flatbush, Bay Ridge and South Brooklyn sections of the city of Brooklyn there is being constructed a sewer some 17,219 ft. long, which is nowhere less than 66 ins. in diameter and which has a minimum diameter of 15 ft. for a distance of 3,765 ft. The lengths and diameters of the several sections of this sewer are as follows: 66-in., 2,100 ft.; 72-in., 1,052 ft.; 78-in., 1,840 ft.; 13½-ft., 3,934 ft.; 14-ft., 3,300 ft.; 15-ft., 3,765 ft.; triple sewer outlet, 1,227 ft. Briefly described, the 66, 72 and 78-in. brick sewer extends along 14th Ave., from 41st St. to 60th St.; this is all circular brick sewer built in open trench. At 60th St., the 13½-ft. tunnel section begins and extends along 60th St. to and along Fort Hamilton Ave., to and onto 62d St. The 14-ft. section carries the sewer along 62d St. to Sixth Ave., thence along Sixth Ave. to 64th St. Here

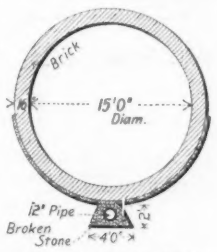


Fig. 1. Cross-Section of 15-ft. Brick Sewer Built in Tunnel.

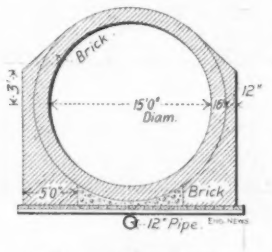


Fig. 4. Cross-Section of 15-ft. Sewer Built in Open Cut.

the section enlarges to 15 ft. diameter, and continues along 64th St. to a rectangular reducing chamber at First Ave. From the reducing chamber a triple sewer continues to the outlet on the bulkhead line of New York Harbor. All of the triple sewer and about 1,310 ft. of the 15-ft. sewer adjacent, were built on trestle and in open cut, but all the remainder of the 15-ft. sewer, and all the 14-ft. and 13½-ft. sewer are being built in tunnel. Altogether, therefore, there are some 9,689 ft., or over 1.8 miles, of continuous tunnel varying from 13½ to 15 ft. in finished internal diameter.

The construction of this sewer was divided into two sections. The first section comprised the 66, 72 and 78-in. brick sewer and 3,870 ft. of 13½-ft. tunnel; the second section comprised 64 ft. of 13½-ft. tunnel and all the 14-ft., 15-ft., and triple sewer work. For the first section O'Brien, Sheehan & Co. were the general contractors, and Mulloy, Coogan & Sexton were the sub-contractors for the tunnel work; for the second section the contractors are the Borough Construction Co. The tunnel work of the first section was quite fully described in Engineering News of Oct. 10, 1901. The present article describes the work of the second section. This work is in direct charge of Mr. James McGrath, Assistant Engineer, Department of Sewers, Borough of Brooklyn, New York city, under Mr. Henry R. Asserson, Chief Engineer. Mr. J. C. Meem is the engineer for the contractors. We are indebted to these three gentlemen for the information from which the following description of the work has been prepared.

CONSTRUCTION AND MATERIALS.

Beginning at 60th St., there come 64 ft. of 13½-ft. sewer, then 3,300 ft. of 14-ft. sewer, then 2,455 ft. of 15-ft. sewer in tunnel, then 1,310 ft. of 15-ft. sewer in open cut, then a reducing chamber, and finally 1,227 ft. of triple sewer.

SEWER TUNNEL.—All the 13½-ft., 14-ft., and 15-ft. sewer built in tunnel is a circular ring of brick 16 ins. thick. Fig. 1 is a section of the 15-ft. sewer in tunnel; the 13½-ft. and 14-ft. sections are similar in form and in all dimensions, except diameter. In constructing the sewer in tunnel it was required by the specifications that the brick work should follow the excavation closely and be built in sections not more than 12 ft. long. It was also stipulated that the excavation must conform as closely as practicable to the outside circumference of the masonry, and that the space between must be filled with brick masonry or natural cement concrete. This filling was to be paid for at the price bid so long as it came within the

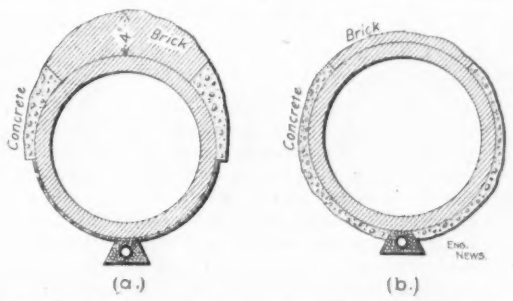


Fig. 2. Cross-Sections Showing Permissible Limits of Excavation Paid for in Tunnel Work.

limits shown by the sections, Fig. 2a and b, or did not exceed 2 cu. yds. per lineal foot of tunnel. It will be noticed that all the tunnel sewer was to be laid on a cradle of 2-in. plank. It was further required that manholes be built to the sewer tunnel at certain points to conform in design and construction to the drawings shown by Fig. 3.

OPEN-CUT 15-FT. SEWER.—About 1,310 ft. of the 15-ft. sewer approaching the outlet were built in open-cut. A cross-section of this open-cut sewer is shown by Fig. 4. As will be seen, the sewer ring is carried by a cradle of brick and concrete masonry resting on a plank grillage. The dimensions and materials used are clearly indicated on the drawing.

REDUCING CHAMBER.—To connect the 15-ft. circular sewer with the triple sewer outlet a reducing or connecting chamber is employed. The details of this structure are shown by Fig. 5. It is built of brick work and concrete and stone masonry. A trench was excavated and sheeted. On the bottom of this trench there was laid a plank grillage, and on this was built a concrete cradle carrying a relieving arch spanning transversely the chamber opening. The relieving arch is of brick, and on top of it is a concrete bed laid to a warped surface as shown. All other parts of

the structure, except the granite cutwaters, are of brick masonry. The concrete used was composed of one part Portland cement, two parts sand and four parts broken stone. The chamber is a very handsome piece of masonry work, as will be seen from the drawings of Fig. 5.

TRIPLE SEWER OUTLET.—From the reducing chamber to the outlet the distance is about 1,227 ft., and throughout this distance the sewer consists of three parallel conduits 8 ft. 10 ins. high and 7 ft. 6 ins. wide, with circular roof arch and invert and rectilinear sidewalls. For 263 ft. this triple sewer structure is built in trench with the cross-section, dimensions and materials shown by Fig. 6. The remaining 964 ft. of the triple sewer structure is brick masonry enclosed in heavy walls of concrete on each side and a concrete roof covering, the whole being carried on a timber platform supported by piles. The details of this construction are of particular interest, and are fully shown by Fig. 7. The construction was described in the specifications as follows:

CONCRETE AND EXPANDED METAL CONSTRUCTION.—The sewer near the bulkhead line for the distance shown on the plans, shall be built entirely of concrete masonry. The inner faces of the triple sewers to be faced with an 8-in. layer of concrete, mixed in the proportions of one part Portland cement, one-half part of sand and 1½ parts of granite dust or powder. All other concrete in this length to be one of Portland cement, two of sand and four of broken stone, of the quality described under heading "Concrete" of these specifications.

As the work progresses, pieces of iron gas pipe will be built in the concrete wall, of proper lengths and sizes, and at the proper places, as shown on the plans, to provide bolt holes for fender piles and fender wales. At the proper places, on the top of the sewer, manholes shall be built. The opening in the brick arch, as well as the concrete arch, shall be circular in shape and to be 21¾ ins. in the clear. An iron rim or head, dimensions as shown on the plan, shall be neatly inserted in the concrete top, carefully bedded throughout; and its interior perimeter be flush in all places with the openings in the top of the sewer. Standard sewer manhole covers will be furnished and set within these rims or heads. In both of the brick division walls of the sewer, at each manhole, there shall be built a circular opening or bull's-eye 3 ft. in diameter.

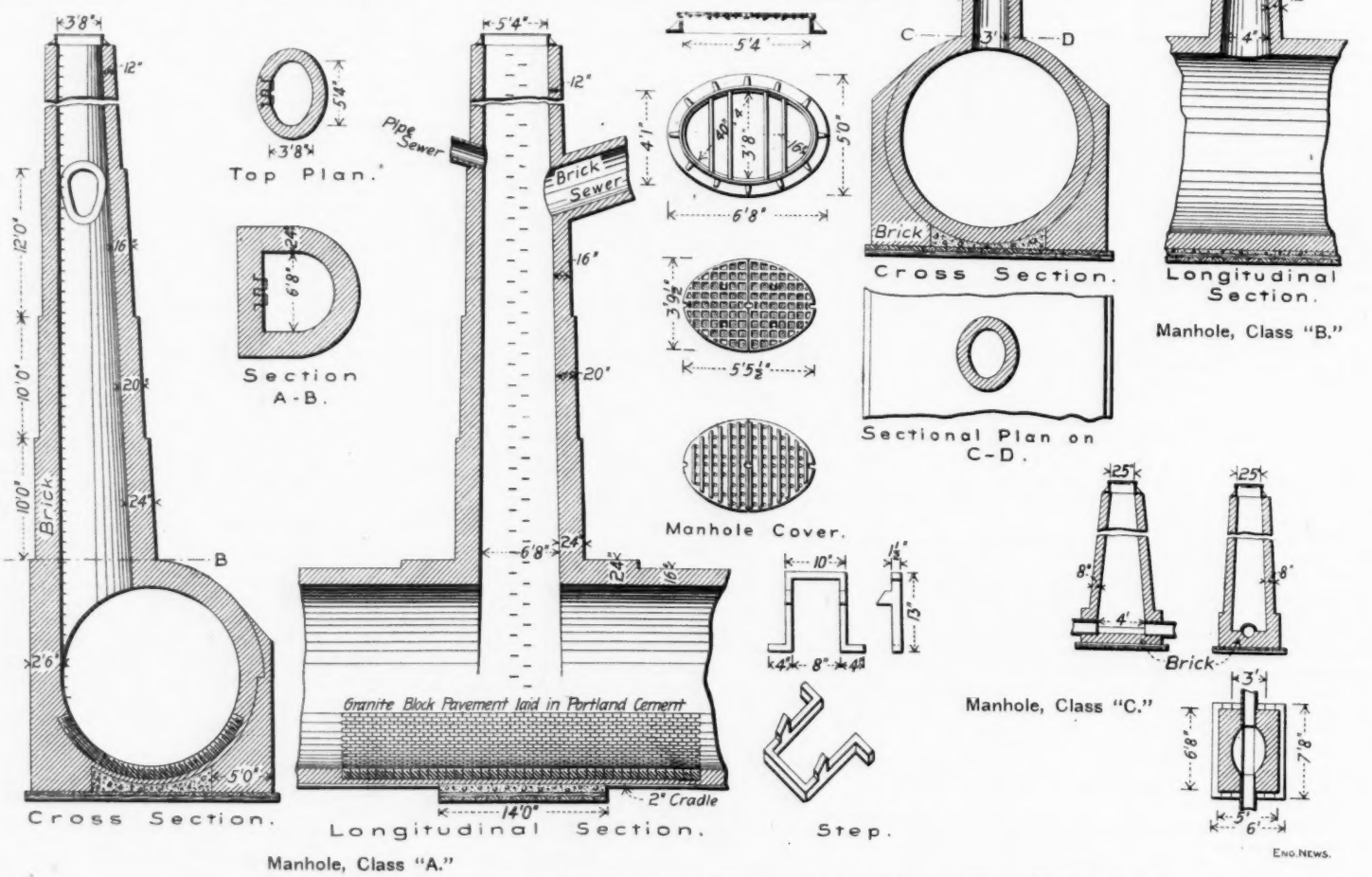


FIG. 3. STANDARD DEEP MANHOLE CONSTRUCTION ON TUNNEL SEWER LINE.

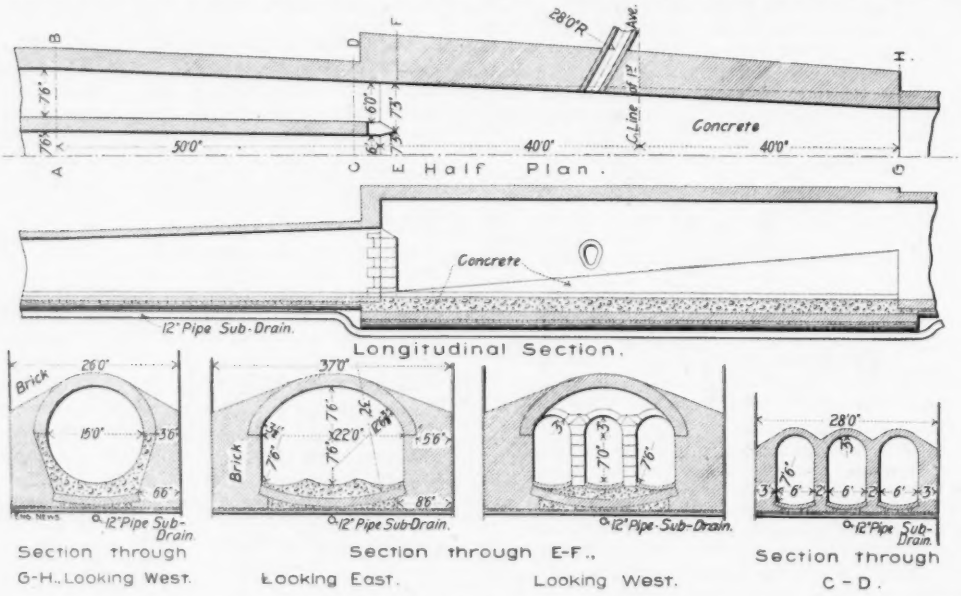


FIG. 5. REDUCING CHAMBER CONNECTING 15- FT. CIRCULAR SEWER WITH TRIPLE SEWER OUTLET.

Within the concrete covering arch, there shall be built sheets of expanded metal; these sheets to be placed in position while the arch is being constructed, and before the concrete has had time to set. The expanded metal shall be in sheets 8 ft. long and 6 ft. wide, the width of mesh to be 6 ins. These sheets shall be placed in the work with their length running transversely to the sewer. They shall overlap both transversely and in the direction of the sewer, one-half mesh, and each sheet shall be carefully wired with No. 16 tie wire, to all adjacent sheets, to maintain them in a proper position while the concrete arch is being built. In no case whatsoever will concrete be laid unless the expanded metal is at hand to be put in place, before the concrete can set. The metal sheets shall be carefully protected from the weather; any that shall be rusted, from this or any other cause, will be rejected and immediately removed from the work by the contractor. The expanded metal shall extend from the upper tie rods of fender piles on one side, through the concrete arch to upper tie rods of fender piles on the other side of the sewer, for the entire length.

WHARF CONSTRUCTION.—Bearing piles, not less than 45 ft. long, will be driven, vertically full length, from the bulkhead line to 25 ft. inland. Their final resistance to penetration shall be as described in these specifications; should the resistance to penetration be greater than there described, the bearing piles for this distance shall be driven with a water jet until 40-ft. lengths are obtained under cut off, indicated on the plans. Other bearing piles, spaced generally 4 ft., c. to c., longitudinally, and as shown on plans, shall be driven vertically with the final resistance to penetration, described in these specifications. All bearing piles, except those in the six oents nearest the bulkhead and each outer longitudinal row along the entire length of the sewer shall be cut off, true and even, 6 ins. above mean low tide, and tenoned to receive the cross caps; those in the six bents and each longitudnial row above mentioned shall be cut off, true and even, 18 inches below mean low tide.

Spur or brace piles, beginning where shown on plans, and extending inland, until a depth of water of 10 ft. at high tide is obtained, shall be driven. They shall be driven at an angle of about 20° from the perpendicular, three to the right and three to the left, and on either side and adjacent to the pile capping over alternate bearing piles. All spur piles within 25 ft. from the bulkhead line will be driven a full length of 46 ft. Their resistance to penetration, and the manner in which driven, within this distance, and in the remaining length, in which they are called for, shall be as described under "Bearing Piles," respectively. They shall be bolted to the longitudinal stringers with 1-in. drift bolts, 21 ins. long, and to the cross caps with two ¾-in. bolts, nuts and washers; a 5-in. filling piece shall be put in between the 6-in. × 12-in. cross-cap clamps, opposite spur piles, and the screw bolts shall pass through pile, caps and filler.

Six longitudinal rows of 12 × 12-in. yellow pine brace stringers shall be placed under and adjacent to the cross caps, as shown on plans. They shall be bolted to each adjacent bearing pile by two ⅞-in. bolts, nuts and washers, and to each 6-in. cross cap with one ⅞ × 21-in. drift bolt. The stringers shall be beveled at each bearing pile to abut it properly. The heads of bolts through stringer and pile to be counter sunk.

Two 6-in. × 12-in. yellow pine cross caps will be placed on each transverse row of bearing piles, beginning at the seventh bent from the bulkhead line and continued inland to the end of the sewer; they shall be bolted together and through the bearing piles by two ⅞-in. bolts, nuts and washers; also to each sheet piling guide wale by 1-in. drift bolts; the under face of the 6-in. caps to be 6 ins. below mean low tide.

Yellow pine caps, 12 × 12 ins., will be placed longitudinally on bearing piles at the outlet end of sewer, as shown on the plans. They shall be bolted to each pile on which they rest with a 1 × 24-in. drift bolt; the under face of these caps to be 18 ins. below mean low tide.

A continuous line of 12 × 12-in. yellow pine tongued and grooved sheet piling shall be driven throughout the entire length of the sewer, on either side of same and across its front, between the bearing piles, shown on the plans. The piles shall be driven closely and their final resistance to penetration shall be as described in these specifications. Across the front and on either side inland for 25 ft., should their resistance under the hammer be greater than specified, a water jet shall be used until their length shall extend 40 ft. under the top face of the bearing pile caps. On the sides of the sewer the sheet piling shall be cut off 14 ins., and on the front 8 ins., respectively, above the 6 × 12-in. pile caps. The sheet piling shall be driven between a double row of 12-in. × 12-in. yellow pine guide wales, the lower pair to be below mean low water and to form a permanent part of the structure. The guide wales on the sides of the sewer to be bolted to the bearing piles by two ⅞-in. bolts, nuts and washers, properly countersunk, and to each 6-in. cap with a 1 × 21-in. drift bolt.

The lower permanent front guide wales will be bolted with a 1 × 21-in. drift bolt to each 12-in. cross cap and sheet pile. The side guide wales shall be bolted to each sheet pile between bearing piles with ⅞ × 21-in. drift bolts; three 3-in. × 4-in. white pine tongues, free from knots, will be used for sheet piles. They shall be properly spiked in the grooves. The sheet piling shall be neatly notched down to allow the 6-in. and 12-in. caps to rest on bearing piles.

There shall be placed on top of the 6-in. cross caps, on the outer side of each row of sheet piling, running with the length of the sewer, 12 × 12-in. yellow pine stringers, which shall be bolted to each cross cap that they cross with a 1 × 21-in. drift bolt. These longitudinal stringers shall also be bolted to each sheet pile with a 1 × 21-in. drift bolt. Beginning where shown on the plan, near the bulkhead line, 1¾-in. iron tie rods, with nuts, washers and turnbuckles, will bolt these longitudinal stringers together, the rods to be passed through the sheet piling. They shall be spaced 12 ft. apart from the point above described throughout the entire length of the sewer.

Outside of the front row of sheet piling, on top of the yellow pine guide wale, an 8 × 12-in. yellow pine stringer will be bolted, with 1 × 17-in. drift bolts. This 8 × 12-in. stringer shall also be bolted to each sheet pile with a 1 × 21-in. drift bolt.

Diagonal corner tie rods, 1¾ ins. in diameter, with nuts and washers, shall be placed, as shown on the plan, bolting the 8 × 12-in. front stringer with the 12 × 12-in. longitudinal stringers.

Corner braces and cleats of 12 × 12-in. yellow pine timber shall be built, as shown on the plans, at the outlet of the sewer, as hereinafter described. They shall rest upon the longitudinal 12 × 12-in. caps, as shown, abutting the inside guide wale of the front row of sheet piling and resting upon the inside guide wales of the longitudinal sheet piling. The braces and cleats shall be bolted to each longitudinal cap with 1 × 21-in. drift bolts. The front cleats shall also be bolted to the inner front guide wale, and the side cleats to each sheet pile, with 1 × 21-in. drift bolts.

In front, and close to each bent of the cross cap bear-

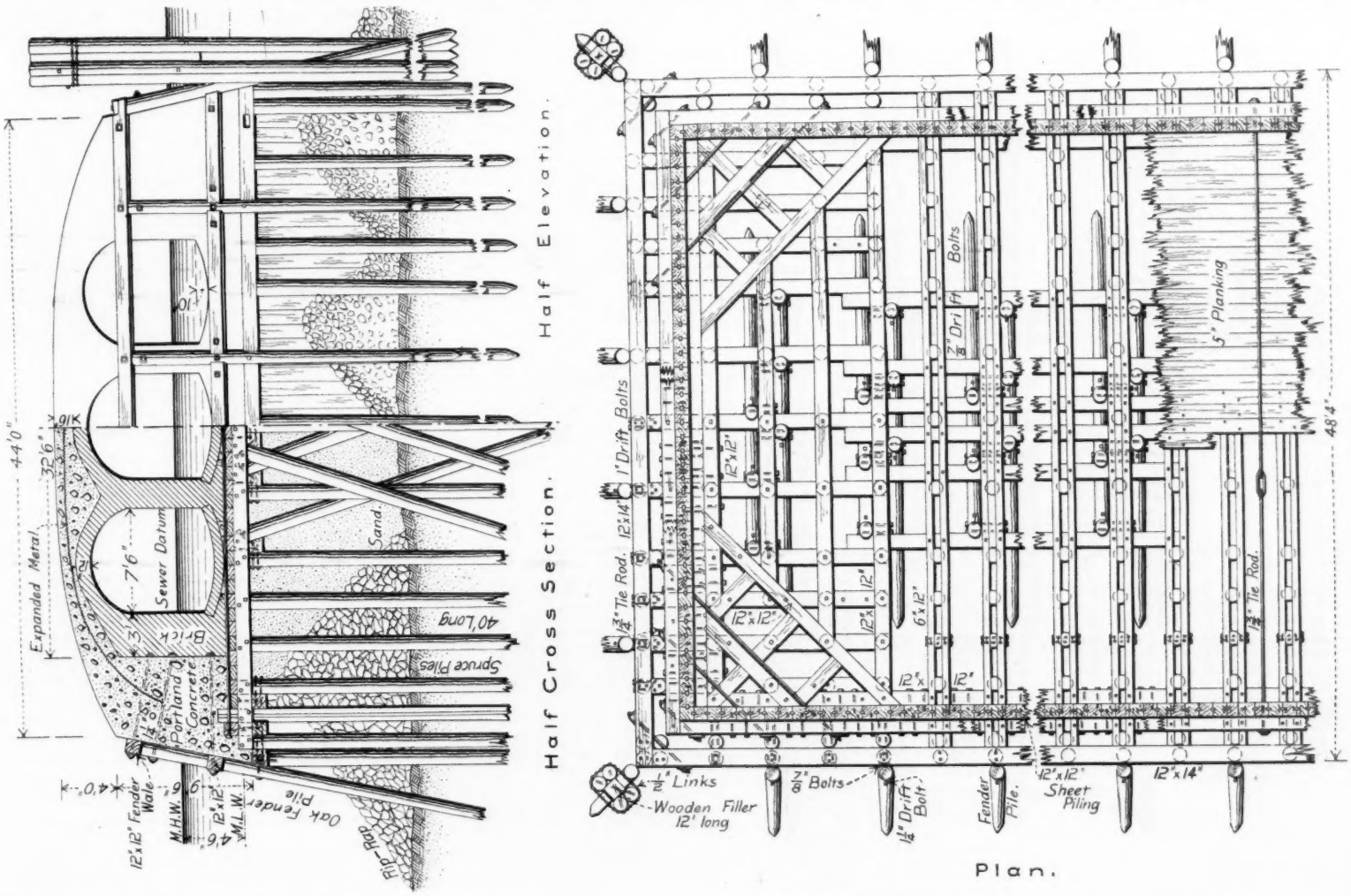


FIG. 7. DETAILS OF TRIPLE SEWER CONSTRUCTION ON TRESTLE PLATFORM.

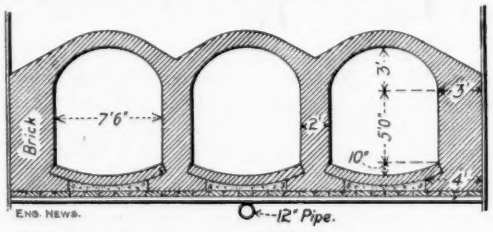
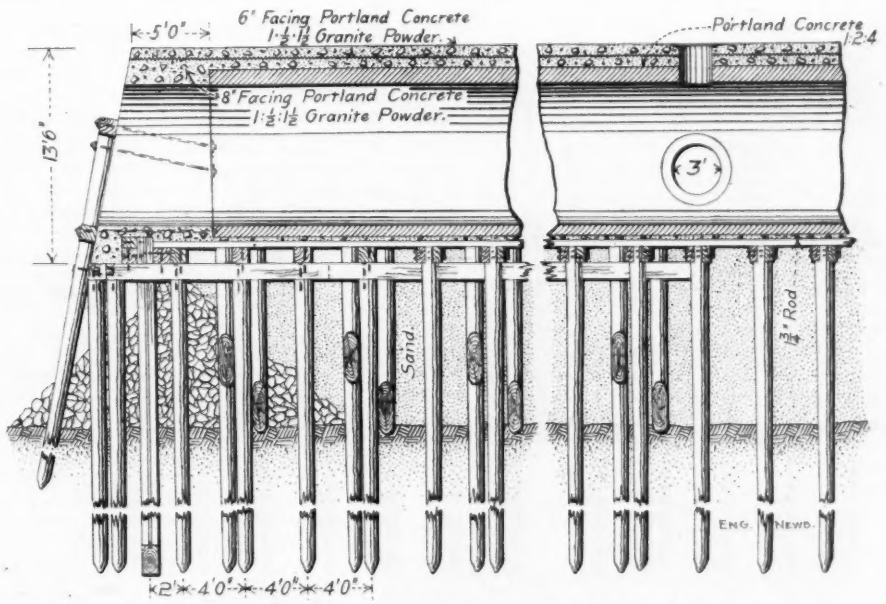


Fig. 6. Cross-Section of Triple Sewer Built in Trench.



ers on these outside bearing piles. The 12 × 14-in. stringers shall be properly beveled where fender piles abut them.

Fender piles of the best quality of oak, sound and straight, 16 ins. in diameter at butt, shall be driven to the final resistance of penetration, as described in these specifications, both for the outer 25-ft. length and the remaining portion of the sewer. They shall be spaced 8 ft. apart, c. to c., along the faces and front of the sewer, as shown on the plans of the work. Piles will be fastened to the concrete spandrel walls with two 1¼-in. diameter screw bolts, nuts and washers. The washers on inner face of the concrete spandrel wall will be ⅝-in. wrought-iron plate 8 ins. square. A 1¼ × 22-in. drift bolt will be driven through each pile into the 12 × 14-in. stringers, as shown on the plan of the work.

At outer end of the sewer, near the bulkhead line, two clusters of four oak fender piles will be driven, in full lengths of 65 ft. each. In between each cluster of four piles a 12 × 12-in. yellow pine filler shall be bolted with four 1¼-in. screw bolts, nuts and washers, as shown on the plan of the work. Near the top of these clusters shall be tightly wound and fastened a wrought-iron chain with links ½-in. thick. These cluster piles shall also be driven alongside of the corner fender piles of the structure.

Two sets of fender wales of 12 × 12-in. yellow pine timber will be fitted in between piles. They shall also be bolted with 1¼-in. diameter screw bolts, nuts and washers; these bolts to have a ⅝-in. wrought iron washer 8 ins. square, on the inner face of the concrete spandrel walls.

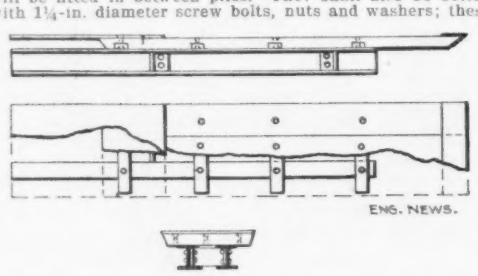


Fig. 9. Details of Special Poling Boards Used in Driving Heading.

Inside of the sheet piling, and on top of the 6-in. cross caps and the 12 × 12-in. corner braces and cleats, a 5-in. yellow pine floor or platform will be laid. These planks will be laid close, breaking joints, and each plank be fastened to each 6-in. cross cap, corner brace of cleat with ⅝ × 12-in. wharf spikes.

After the sheet piling, brace piles and bearing piles are driven and before the 5-in. flooring is put in place, riprap stone shall be deposited and well packed behind and in front of the sheet piling, as shown on the plans of the work. Sand filling, as shown on the plan, will be deposited inside of the sheet piling and riprap, after the riprap is in place and before the 5-in. flooring is laid. It shall be clean, sharp and free from loam.

MATERIALS.—The principal materials required in the work being described, were brick and stone masonry, cement mortar and concrete and piles and lumber. The specifications for brick and stone masonry materials and workmanship were such as are usual for important first-class work. The following is a brief abstract of the specifications for mortar, concrete and piles:

CEMENT AND MORTAR.—All mortar is to be composed of one part of fresh ground hydraulic cement of the best quality, and two parts of clean, sharp sand, entirely free from loam. It is to be carefully and thoroughly mixed dry, and a sufficient quantity of water is to be afterward added to make it of good consistency. The mortar is to be mixed in no greater quantity than is required for the work in hand. Any excess that may be left over at night, or that may have been standing long enough to set is not to be retempered or used in any way. All cement must be delivered on the ground in well-coopered barrels, and not in bags nor in bulk, and the contractor will be required to furnish the engineer full facilities for testing the same; all cement found to be of improper or inferior quality must be immediately removed from the work. All cement, except Portland cement, shall be 90% fine when tried with a sieve of 2,500 meshes to the square inch, and shall be subject to either of the following tests: Neat cement made into testing blocks, after 30 minutes' exposure to air and 24 hours' immersion in water, shall withstand a tensile strain of 75 lbs. per sq. in. for Rosendale, and 160 lbs. for Portland cement. Portland cement, after exposure in air for one day and six days in water, shall withstand a strain of 350 lbs. per sq. in., and when mixed with two parts of sand, after one day in air and six days in water, a strain of 125 lbs.

CONCRETE.—All broken stone shall be "machine broken," of hard, sound granite, trap rock or silica sea-washed gravel to be approved by the engineer, and of a size that will pass through a 1¼-in. ring; it must be free from dust and dirt, and, if ordered, must be thoroughly screened and washed before being used; piles or heaps having any admixture of dirt or stones of a larger size shall not be used for concrete. The cement and sand must be up to the standard prescribed in these specifications for mortar. Concrete shall be made in the proportions of one part, by measure, of cement, two of sand, and five of broken stone, except the concrete specified for the outlet sewer. The cement and sand shall first be made into a rather stiff mortar, then the stone will be added, and the whole mass quickly and thoroughly mixed in a box made for that purpose by turning it over three times with shovels. Concrete must be lowered into the trench in boxes or buckets, and will in no case be allowed to be cast in by shovels from the surface; it shall be deposited in layers not less than 4 nor more than 9 ins. in thickness, and must be settled into place by ramming sufficiently to flush the mortar to the surface. When in place all wheeling, working or walking over it must be prevented until it has set sufficiently to escape injury. When connection is to be made with any layer, set or partially set, the edge of such layer must be broken down, all loose material entirely removed, the surface swept off and thoroughly wet, so as to make the joint fresh and close.

PILES.—Whenever piles are required for foundation they shall be furnished of good, sound pine or spruce, free from shakes. They shall not be less than 12 ins. in diameter at the butts, and shall be property sharpened and shod with approved iron shoes when required, and shall be driven with a hammer of not less than 2,000 lbs. in weight, and driven to solid bottom or until the pile shall not yield more than 1 in. under the blow of the hammer falling 15 ft., or until the pile has reached a depth of 80 ft. The tops to be sawn or cut off truly and evenly to the grade furnished; care shall be taken to protect the heads of the piles by rings or otherwise if necessary, so that they shall not be split or broomed to a condition unfit to receive the cap. No pile shall be lengthened by blocking or using a follower. Any pile found too short to comply with above conditions shall be drawn and a longer one substituted. When sheet planking is necessary and intended to remain, it shall be furnished of good pine or spruce plank, of proper length, width and thickness; it shall be sound, free from cracks, shakes and sap-wood. The plank shall be tongued and grooved for the whole length of the pile, if required by the engineer, and shall be driven with the ram so as not to crack or split.

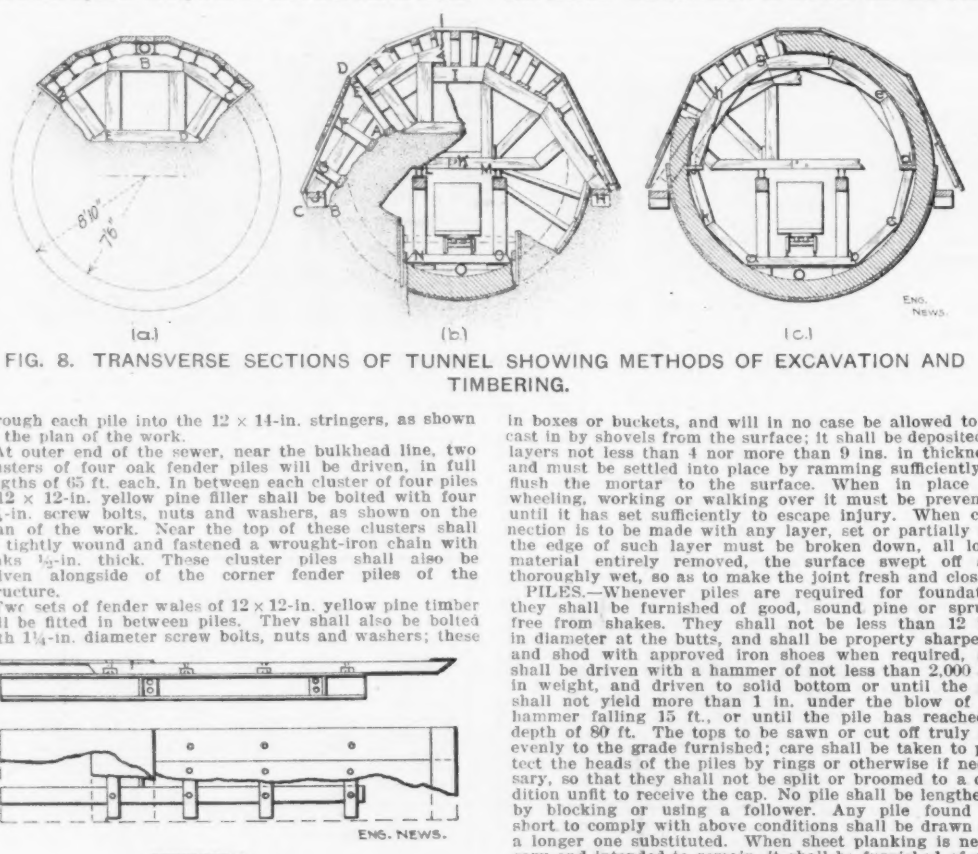


FIG. 8. TRANSVERSE SECTIONS OF TUNNEL SHOWING METHODS OF EXCAVATION AND TIMBERING.

METHODS OF CONSTRUCTION.

The total amount of sewer built in tunnel on the portion of the work being described was 5,849 ft., of which 64 ft. were 13½ ft. in diameter, 2,455 ft. were 15 ft. in diameter, and 3,300 ft. were 14 ft. in diameter. According to the plans and specifications, this tunnel was to be constructed from six line shafts and a portal shaft, and the method of tunneling adopted must be one which had been "successfully employed elsewhere in similar strata and be equally as reliable and rapid as the Anderson pilot method." The method adopted was one devised by Mr. J. C. Meem, Civil Engineer for the contractors, and previously used by him in the construction of Chatham Square sewer for the New York Rapid Transit Railway (Eng. News, March 20, 1902), and a combination of this method and the Anderson pilot method.

MATERIALS PENETRATED.—The subsoil penetrated by the tunnel being described is a fine sand, having a small admixture of clay in places and carrying a considerable amount of water. While hardly deserving to be called quicksand, this material will not stand up at all under excavation, making necessary strong timbering and tight lagging to keep it in place. At intervals, moreover, boulders of considerable size are encountered.

MEEM POLING BOARD METHOD.—The mode of procedure with the special poling board method devised by Mr. J. C. Meem is illustrated by Figs. 8 to 10. In this method the first work is to take out a top heading embracing about a quarter of the perimeter of the section. The first operation is to erect the segmental guide frame A B C D E (Fig. 8a). Over the top of this frame is slipped the ends of five poling boards constructed as shown by Fig. 9. These poling boards are gradually pushed ahead into the soil and excavation is carried on underneath their cover. After the poling boards have been pushed ahead a little distance another guide frame is erected ahead of the first, and when the work has proceeded still further a third frame is inserted. The five poling boards are now being carried and guided by five frames, which is the normal arrangement when the work has been fully started, as is shown by Fig. 10.

The next step is to carry down the excavation on each side of the first cut following the perimeter of the section, as indicated at A B C D, Fig. 8b. During this operation the roof is braced by the struts E, F, G, etc., which support lagging boards. As soon as the side cuts have been completed the segmental frame timbering indicated at H I J K is erected and struts are inserted between its top and the roof lagging to relieve the poling boards and previous timbering. The excavation is then carried down along the perimeter of the section, using radial bracing and lagging to carry the sides of the excavation until the section has been opened sufficiently to permit the construction of a portion of the invert brick work. The timbering L M N O is then erected on this invert masonry to carry the segmental frame. The excavation is now ready for the completion of the lining masonry. To build this the segmental centering frames a b c d e f, etc., Fig. 8c, are built and lagged for the roof arch. These frames are built between the timbering frames, as shown by Fig. 10.

The general features of the method of work under description are made fairly clear from what proceeds; some of the minor details will now be considered. The construction of the poling boards or needles used in driving the heading calls for only brief mention. As will be seen from Fig. 9, they have steel-shod cutting edges and a steel plate tail-piece. In operation this tail-piece overlaps the roof lagging behind just as the tail of a tunnel shield overlaps the cast-iron lining behind and thus leaves no unsupported roof during excavation. The poling boards are driven ahead by 30 and 60-ton hydraulic jacks operated from hand pumps. Fig. 11 shows a number of these poling boards completed and under construction, and Fig. 12 is a view from the face of the heading looking back toward the shaft, which shows the poling boards and guide frames in position in the actual work. Generally speaking, the face of the heading was kept about 30 ft. ahead of the brick work, this length of timbering being sufficient to take the thrust of the jacks without distortion. Fig. 13 is a view showing the segmental timbering frames.

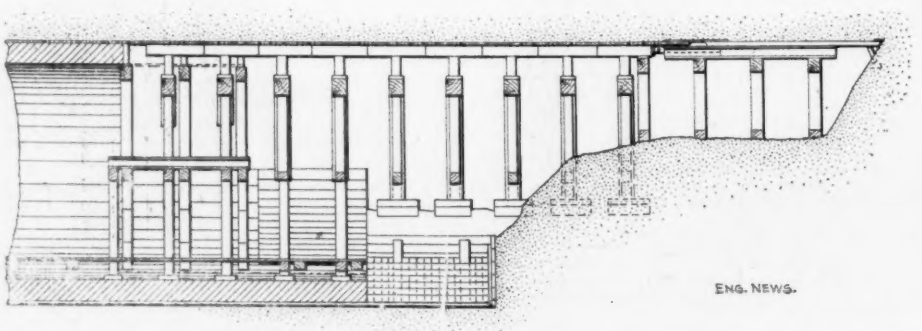


FIG. 10. LONGITUDINAL SECTION SHOWING METHODS OF TIMBERING AND EXCAVATION.

COMBINATION METHOD.—In the combination

method of work a top heading is driven in the manner already described. An Anderson pilot is then driven into the bench behind, the excavation being done through and around the outside of this pilot, which serves as a hub for radial bracing, in the manner familiar to engineers, and as shown

Fig. 11. View Showing Special Poling Boards Under Construction.

by Fig. 14. Fig. 15 is a view showing the shaft-head plant at one of the principal main line shafts.

DOES MANURE ROT CONCRETE?

Now that freezing weather is prevalent various experiments are adopted to prevent freezing of concrete—some new, some old.

Manure is occasionally used to cover up fresh concrete in freezing weather, not only because it is a good non-conductor of heat when in a rather dry state, but because in its decomposition a considerable amount of heat is given off.

A contractor of considerable experience in masonry work recently told us that he once paid dearly for learning that manure rots concrete. It seems that he had built a Portland cement concrete wall about two feet high and two feet wide, when severe freezing weather stopped further work. He covered the newly laid wall with manure banked up against its sides and over its top. A week later, when the weather had moderated, he removed the manure expecting to find his concrete wall well hardened.

Instead, he found it very much disintegrated; so much that the outer part could be scaled off with the fingers. He ultimately tore the whole wall down, readily picking it to pieces with light blows of a pick.

It may have been either the ammoniacal gases given off by the decomposing manure, or it may have been the uric acid seeping downward that acted so disastrously upon the concrete.

We are, however, more concerned with the fact than with the theory, and we should be glad to

Fig. 12. View from Face of Heading Showing Poling Boards and Guide Frames.

hear from any of our readers who have used manure in a similar way, stating whether such use has been satisfactory or not, and stating whether the manure contained much or little straw.

THE COST OF HYDRAULIC MINING.

In our issue of Nov. 27, 1902, a considerable amount of data was given relative to the cost of hydraulic excavating and mining. From a recent contribution to "The Mining and Scientific Press" we abstract the following:

The property to be described is in California, and some considerable capital has been expended there for the bringing in of water, as well as on the purchase price of the ground itself. The water is conducted to the mine by flume and ditch a total distance of 30 miles, having a capacity of 3,000 miners' inches. The nature of the ground through which the ditch is cut, the steep slope of the hillsides and the severity of the winters cause the expense of maintenance to be rather high, aggregating about 22% of the total exploitation expenses. During the earlier years of the company's existence their water right, even in favorable seasons, never yielded over 450,000 miners' ins. More recently, however, by advantageous reconstruction, this has been increased until from 650,000 to 750,000 miners' ins. are obtained, according to the winter. This big supply of water—a daily average of 3,000 miners' ins. during eight months—cannot be utilized constantly with profit in only one spot. For good work it is necessary to have several points of attack, thus allowing changes of water, moving of machines, clean up and other contingencies to be overcome without complete suspension of operations. The water supplied last season was used in the following way:

First mine	82%
Second mine	13%
Electric lights, derrick, irrigation	5%

This unequal distribution between the two mines is one of intention, and due to the nature of the bank to be washed. The first is of loose gravel with slides and cracks for over one-half mile. Here our efforts have been concentrated, as the other place is characterized by a hard cement, requiring a special installation to be worked with profit.

Both mines consist of gold-bearing gravels, with material of every size from pebbles to boulders of 2 to 3 cu.

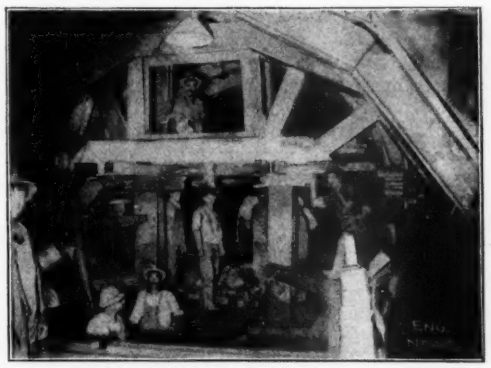


Fig. 13. View Showing Method of Timbering.

yds., requiring water, powder and derrick for their removal.

The bank is broken by four giants; one on the front with a head of 400 ft. and nozzle 7 to 9 ins., according to circumstances; two on the left side with 150 to 250-ft. heads, and one on the right side with 500-ft. head, to break the cement.

The gravels vary in thickness from 2 ft. to 250 ft., bearing gold throughout.

Broken by the side giants, the bank is prevented from sliding too far by the front giant. (I have seen the bank slide ahead as much as 100 ft. in 24 hours.)

The bank being for the most part loose, this sliding is, of course, induced by the piping. For this reason the entrance of the sluice is kept at a safe distance—usually about 150 ft. away—and the front giant always settled at the head of the sluice.

The sluice is 6 ft. wide by 4½ ft. deep, with the boxes 12 ft. long. At the beginning of the last mining season I had down 56 boxes, and at the end of the run 118, of which additional number 14 were at the head and 48 at the lower end. The grade is 8 ins. to the box (12 ft.). The bottom is laid with blocks in the first ten boxes and boulders in the others. Two undercurrents collect the fine gold very satisfactorily.

I termed it "low-grade" gravel because numerous panning tests during the season showed an average of from 4 to 6 cts. per cu. yd. (These tests do not include the prospects which induced the company to buy the property.) Despite this small percentage, I have been able to reach some satisfactory results. To show this in figures, the following table is prepared, and, for the sake of comparison, the results of several years are embodied there; also the last season, being the only one coming under the present management. I have referred the total amount of expenses and returns to the miners' inch:

Cost and Returns Per Miners' Inch.

	1895.	1896.	1897.	1898.	1899.	1900, 9 Mo.	1900-1901.	1901-1902.
Cost.....	$0.136	.106	.095	.1004	.866	.0081	0.0855	.08219
Returns.	0.136	.125	.136	.103	.100	.0738	0.0663	.1418

The volume of gravel washed out is not very easy to get at, because for over half a mile in length the outside lines of the bank are changing continually. Without entering into any hair-splitting mathematics, however, I have estimated that between 2½ and 3 cu. yds. are moved per miners' inch of water used. [At a cost of 2¾ to 3¼ cts. for 1901-2; and 600 to 700 cu. ft. of water were required to move 1 cu. yd. of gravel.—Ed.] By an approximate triangulation of the area worked over in former years, I find that during last winter about two and a half

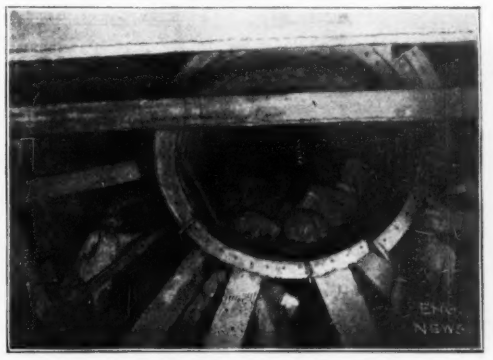


Fig. 14. View Showing Anderson Pilot and Radial Timbering.

times as much gravel was moved as in any previous season. No changes in the character of the bedrock have been encountered.

In order to obtain these results, I have practiced the following:

1. Increase of pressure on the giants.
2. Heavy run in the sluices.
3. Increase of responsibilities and, consequently, of some salaries.
3. Decreasing number of laborers by using more water power.
5. Three times a week a careful inspection of flumes, pipe line, sluices, derricks, etc.

The distribution of the gold, as caught in the sluice boxes, is as follows:

	Boxes.	Per cent.
First section	15	73.5
Second section	30	13.4
Third and fourth sections	71	1.6
Undercurrent	..	11.5

To show the exact proportion of all expenses during the running year, the following table has been prepared:

Classification of Expenses Per Miners' Inch.

		Per cent.
Piping and sluicing	$0.01224	15
Lengthening sluice	0.00078	
Moving machinery	0.00045	2½
Moving derricks	0.00071	
Moving boulders	0.01285	16
Cleaning up	0.00065	
Electric lights	0.00134	6
Blacksmithing	0.00136	
Carpentering	0.00187	
General repairs	0.00507	6
Lumber and powder	0.00668	8
General supplies	0.00422	5
Ditch, maintenance	0.01534	22
Ditch, supplies	0.00247	
Reservoir	0.00110	2½
Stable and teams	0.00110	
Taxes	0.00422	5
General expenses	0.00979	12
Total	$0.08219	100

From this it is evident that a long sluice is unnecesary, the coarse gold always stopping in the first boxes and the fines being caught in the undercurrent.

Fig. 15. View of Shaft-Head Tower and Engine-House.

From this it is observed that 50% of the total expenses is made up of the following: Ditch, 22%; sluicing and piping, 15%; general repairs, 12%.

My experience shows that low-grade placers can be worked with some profit; but it requires very close attention to the details, for the wasting of the smallest fraction of a cent per miners' inch of water used may imperil the future welfare of the mine.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

"A Sacrifice to the Dangers of the Train Order System of Railway Operation." That is the epitaph which should be written for the twenty-eight unfortunates who lost their lives in the head collision at Wanstead, Ont., on Dec. 26. "But," says the conservative railway official, "you know accidents happen under any system. You must trust somebody, and the best of employees will make mistakes."

Perhaps the best answer to argument of this sort is the fact that on the very same railway, the Grand Trunk, on the previous night, and only a couple of hundred miles or so from the scene of the first fatal wreck, another butting collision occurred in which the lives of four men were wiped out.

Does this give a fair idea of the frequency of butting collisions, or was it merely a remarkable and unusual coincidence? For an answer we turn to the record of other accidents for the current week. We read the report of a freight collision on the Colorado Southern on the night of Dec. 24, in which from 15 to 30 lives are reported lost. We read of a collision on the Pittsburg, Virginia & Charleston, a day earlier, in which one man was killed and half a dozen others seriously injured. Another on the Pittsburg & Western, claimed two victims.

These are but samples taken at random; but we respectfully submit them as competent evidence against the contention of the conservative man that the time-honored (or shall we not better say time-dishonored) train order system is about as safe as any system that can be devised.

The essential defect of the train dispatcher system of moving trains is well illustrated by the investigation now in progress before the coroner's jury. As usual, there is a conflict of testimony between the operator and the train dispatcher as to which made the mistake that sent the two trains against each other, but it really makes little difference which one of them made the mistake. The essential point is that 28 people are dead and 40 others lie in the hospital, many of them maimed for life, and that a single mistake of one man caused this. Which shall we blame most, the man who made the mistake or the system that hangs such huge risks on such a slender thread?

Men will make mistakes. Of course they will. The weak point of the train order system is that it breaks down with resultant disaster every time a mistake is made. The only system fit to be used in modern railway service is a system which interposes mechanical checks and safeguards against human liability to err.

Until some such system is universally adopted in American railway service such sacrifices of lives and limbs as that recorded this week must continue.

The Grand Central Station in New York city, used by the New York Central & Hudson River and New York, New Haven & Hartford railways, is to be remodeled on an extensive scale as an indirect result of the Park Ave. tunnel collision a year ago, and of the public agitation which followed that collision, for the use of electric power in the tunnel.

As some of our readers may remember, the first plan of the railway company, when it awoke to the fact that something must be done, was to operate only the suburban trains by electricity, and still continue the use of steam locomotives for all through trains. In order to carry out this change and to make at the same time needed additions to its yard space at the Grand Central Station, it became necessary to obtain certain consents from the New York city authorities. These consents are now in a fair way to be granted, but the final result is that the changes will be of a much more radical character than was first contemplated. For example, the level of the yards, which extend from 44th St. to 56th St., will be lowered from 7 ft. to 16 ft. in order to enable overhead viaducts to be constructed to carry the cross streets over the tracks.

The feature which is of greatest interest to engineers, however, is that the entire operation of trains, through as well as local, is to be by electricity, and it is stated that electric operation (of passenger trains) will be extended to Croton on the Hudson River Division, 34½ miles from the Grand Central Station, to White Plains, on the Harlem division, 22 miles out, and to an unstated distance on the New York, New Haven & Hartford. This installation will be by far the largest use of electric power for steam railway service ever attempted.

As we have before pointed out, this adoption of electricity has been to a large extent forced upon the company by the pressure of public sentiment, and not because the responsible officers saw any advantage, economical or otherwise, in the use of electricity commensurate with the enormous expense necessary for its installation. The entire work is to be completed within five years, and the expense is set by popular report at $25,000,000, including all necessary track changes. It is a little difficult to see how the traffic facilities which the company will possess when the entire work is completed will be sufficient improvement over those now existing to enable dividends to be earned on this large additional capital.

Apropos of the letters published in this issue concerning the meager compensation of engineers, we are very glad of the opportunity to show another side of the story, and to call attention to a case where engineers have received a fee, which, while not at all large in comparison with the fees of distinguished lawyers or surgeons, is yet munificent compared with the fees too frequently allotted for important engineering work.

The commission of three consulting engineers, appointed to report on an additional water supply for New York city, are to receive a fee of $12,000 each. Their report is to be presented by Nov. 15 next, so this fee covers practically a year of service. Of course this work will not occupy the whole time of the commission by any means. Each of them continues his regular consulting practice, just as any lawyer would continue his practice of law, notwithstanding the fact that a single important case involving a large responsibility and proportionately large fee, might engage much of his attention.

It is unfortunately true, as our correspondents point out, that the engineer is generally paid a very inadequate salary considering the responsibilities that are laid upon him. With over 15,000 students now in the engineering schools of the United States, we do not see how the market rate for engineering work in the lower grades can well be raised. It is of interest and of decided encouragement, however, to see the services of engineers at the head of the profession occasionally rated at a fair valuation, such as is commonly allotted to work done by other high class professional men.

The hearing on the waste of water in New York city granted to the City Club last week by the new engineer-commission on water supply and waste was a commendable proceeding on the part of both the commission and the club. Nevertheless it was amusing to hear a number of lawyers and business men eloquently explaining the subject of water waste and the usefulness of meters to the eminent engineers composing the commission. One man(not a representative of the City Club, however,) took the trouble to prepare and present to the commission a table showing the quantities of water flowing through small orifices under various pressure!

Of course the real value of the hearing was in its educational influence upon public opinion, and its assurance to the commissioners that there does exist in the community an organized group of men who appreciate the enormity and the evil of the water waste now going on, and who realize that meters are the best agents to reduce that waste. We trust that more such opinions will be expressed to the commission and brought forward in the public press, so that the commissioners may be encouraged to act upon their convictions and may recommend prompt measures to discover and restrict waste instead of assuming that waste restriction will be too unpopular a measure to be politically possible.

That assumption was unfortunately made at the time of the Ramapo agitation a few years ago, both in the report of the Merchants' Association experts and in the report made by Mr. Freeman. In fact, the array of facts respecting water waste in the two reports, coupled with the failure to act on these facts and to recommend the application of the logical remedy for water waste, will be looked back upon, years hence, as one of the strangest features in the long struggle to secure the adoption of ordinary business methods in the distribution and sale of water.

That failure really affords the City Club some justification for bringing forward anew the well-known arguments against water waste. As the speakers for the Club well said, three years have elapsed since the reports above-mentioned were published, and practically nothing has been done either to provide a new supply or to curtail waste, the need for one or both of which was so forcibly shown by the reports.

Even if it is assumed that an enormous additional water supply is needed, it must by this time be evident that waste prevention is the most effective and economical, if not the only way of guarding New York city against the water famine which will constantly threaten it during the many years that must elapse before any additional supply can be made available.

The first and most imperative need, if a campaign of water waste prevention is to be started, is to provide some means of accounting, in bulk, for the water sent into the various boroughs and minor districts of the city, in order to determine where the greatest waste occurs. This, we understand, is to be done by the Department of Water Supply, Gas and Electricity.

Similar work has already been started by the Metropolitan Water and Sewerage Board, at and near Boston, as noted briefly elsewhere in this issue. We may add, as the latest contribution to the long tale of needless waste, that during the recent cold snap the total daily water consumption in the Massachusetts Metropolitan District rose from an average of 102,228,000 gallons for the month of November to 133,560,000 gallons for the week ending Dec. 13, and that on one day of that week the consumption was 151,000,000 gallons, thus showing, on the authority of Mr. Dexter Brackett, M. Am. Soc. C. E., Engineer of the Distribution Department of the district "that during cold weather from 30,000,000 to 50,000,000 gallons per day were wasted to prevent freezing of service pipes." The per capita consumption for November was 116 gallons, but during the cold week mentioned it rose to 151 gallons. The time has certainly come when American municipalities should no longer tolerate such wholesale waste.

In a recent issue (Dec. 11) we gave a food or ration list for men going on a camping expedition; but as an accessory to that list it would be well to add such medicines, and the like, as would form a light, compact medicine kit. If any of our readers have had experience in getting up such a medicine kit for a surveying or prospecting party a description of it would be of interest to many readers. We ask, therefore, that facts relating to such medicine kits be sent to us.

SOME QUESTIONABLE THEORIES CONCERNING ORE FORMATION AT MONTE CRISTO.

In a monograph on the ore deposits of Monte Cristo, Washington, by J. E. Spurr, of the United States Geological Survey, we find some very positive statements based upon very slender data. This, however, is no unusual procedure on the part of some geologists and mining experts; but it seems time that a protest be entered against just such sweeping generalizations, especially when the reasoning is so open to attack.

It may be asked what harm can come from the publication of one man's opinions, however crude may have been his reasoning. Ordinarily, no great harm does come from such extremely theoretical dissertations; but the investing capitalist is quite apt to regard the members of the U. S. Geological Survey as being unbiased experts whose opinion is worthy of great weight. This is as it should be, perhaps, but such being the case there is all the greater reason why a writer of authority should express himself guardedly and not dogmatically upon matters at least subject to debate.

A member of our editorial staff visited this same Monte Cristo district after it had been opened up, and remained there for several months. We have, therefore, been especially interested in studying what Mr. Spurr has to say of the ore formation of the district. Mr. Spurr says, without any qualification and with great positiveness, that the ores have been deposited by descending waters, and within comparatively recent times, certainly since the existence of present topography. He adds that there are abundant proofs of this, but when we look for the abundant proofs, we find four given: (1) that ore is often found in the bottom of troughs formed by intersecting joints; (2) that the footwall is the favorite place for deposition; (3) that no warm or ascending springs are to be found in the district, or in most of the rest of the Cascade Mountains, while there is a great annual precipitation of water that must find its way downward through the country rock; and (4) that the upper minerals being the easiest of precipitation indicate downward motion of the solution. From these alleged facts Mr. Spurr argues that the best ores may lie near the surface, and the character of the ore will change with depth.

At the time that the member of our editorial staff was at Monte Cristo, there was no evidence at all of the existence of ore deposition on the footwall of the veins in any way distinguishable from the hanging wall deposition. Upon examining Mr. Spurr's statement of the alleged fact that ore was largely deposited on the footwall, we find no very definite wording to that effect after all, but the use of some such expression as "favorite place" for deposition. But even that the footwall is a "favorite place" for ore deposition at Monte Cristo may well be doubted.

Passing to the inference drawn from the fact that there are no hot springs in the Cascades, we fail to see the force of any argument based thereon; for it must be admitted that while the presence of hot springs may be used to prove certain theories, their absence proves nothing at all. Hot springs are not to be found near the copper deposits of Lake Superior. Does it follow then that the copper was precipitated from descending cold waters? Not at all; the absence of hot water now in no wise makes improbable its existence in times past.

For sake of argument we have granted that hot springs do not exist in the Cascades. As a matter of fact we know of at least two hot spring districts in the Cascade Mountains, neither of which is far from Monte Cristo. About 35 miles south of Monte Cristo are the Green River Hot Springs on the line of the Northern Pacific Ry.; and just over the Canadian boundary line to the north are the Harrison Hot Springs—both in the Cascade range.

It would seem that the writer of ore formation theories should at least be aware of such geographical facts as these.

As for the present great rainfall on the west slope of the Cascades, as an argument for the theory of descending mineralized waters, what shall we say: Richer veins, as a matter of fact, exist in many parts of Washington, and other states where rainfall is comparatively slight; per contra, ore deposits have never been shown to "favor" rainy districts.

Had Mr. Spurr shown by actual analysis of the cold spring water, that it now carries the sulphides or their derivatives, and had he shown that the hornblendic granite in which the veins lie carries the vein matter disseminated through its mass, he would have some reasonable basis for his theory. But to reason from questionable assumptions of alleged facts to dogmatic assertions of what has occurred—it is just this that we object to.

It is quite likely that the character of the ore will change with depth; but that it will decrease in richness is by no means proved. Even if the upper ores are sulphides easiest of precipitation, we would suggest that it is quite as possible for the precipitation to have occurred in the present order by ascending solutions. Moreover, if these sulphides were chemically precipitated, as assumed by Mr. Spurr, in very recent times and from cold water solutions, how does it happen that the precipitated sulphides are crystalline, when crystallized galena, for example, has never yet been made in laboratory experiments under similar conditions? The laboratory precipitates of metallic sulphides are flocculent—not crystallized like the sulphides at Monte Cristo. To us this irreconcilable difference alone seems to upset any descending cold water theory.

It is all very well to search for a true theory of ore making in any particular locality, but until the fundamental principles of ore formation are better understood it is not only injudicious but actually reprehensible for a writer in a position of some authority to talk as if his guesses were to be accepted as incontrovertible facts.

It is much easier to give opinions than to make chemical analyses of rocks and waters, but after all is not an ounce of the laboratory method of investigation worth a ton of words?

LETTERS TO THE EDITOR.

The Failure of a Wooden Water Tank at Madison, Neb.

Sir: Referring to Mr. Koenig's description of the failure of a water tank at Madison, Neb., in your issue of Dec. 18, the fact that the tank fell to the up-hill side, while only the trestle support on the down-hill side gave way, is easily explainable if we assume that the primary failure was not in the supports, but in the floor of the tank itself. The water escaping through the hole in the bottom would have an effect similar to that of the gases escaping from a skyrocket, and would tend to lift and overturn the tub precisely as Mr. Koenig describes.

The falling of the trestle "D" (Mr. Koenig's diagram) was an effect, and not a cause, of the disaster.

The foregoing assumption is sustained by the statement of eye-witnesses that water gushed down between bents "C" and "D" before the tank toppled over.

J.

Pittsburg, Pa., Dec. 22, 1902.

A Correction in Centrifugal Machine Formulas.

Sir: In your valued paper of Dec. 11 I note a correction that should be made to one of my formulas. In the issue of Dec. 11, 1902, p. 507, the equation reading:

$$A = \frac{\pi d_1^2 - d^2}{4}$$

should be:

$$A = \frac{\pi (d_1^2 - d^2)}{4}.$$

Again, instead of $\frac{K Q}{\pi^2 d^2 h^2 \tan^2 \alpha}$, there should be $\frac{K Q^2}{\pi^2 d^2 h^2 \tan^2 \alpha}$.

With these changes the final formula becomes

$$h = \frac{Q}{2\sqrt{\pi \tan \alpha}} \sqrt{\frac{K}{G}},$$

from which it follows that the lifting of the basket is proportional to the quantity (Q) of oil flowing.

These corrections will also appear in the final issue of the "Transactions of the American Society of Mechanical Engineers." Very respectfully,

B. Viola.

11 Bartlett St., Brooklyn, N. Y., Dec. 17, 1902.

The Reliability of a Hydraulic Engineer's Estimate.

Sir: In your issue of Dec. 18, under the head of "Notes and Queries," I notice an anonymous communication which is emphasized by a quizzical and exclamatory mode of expression, concluding with an imputation as to the reliability of estimates, in general, made by hydraulic engineers; as one of them, I take a lively interest in such criticisms, and should beg leave to inquire what source of information other than the article mentioned, led our unknown friend to the conclusion that the available head in question was only 50 ft.? As I read the article, I notice that a "fall at Bull Sluice Shoals" is mentioned, height not stated, which fall would usually be added to the head of the dam itself; and, furthermore, there seems to be nothing stated in the article which would preclude the idea that there might be a long flume utilizing a still greater fall in the slope of the river bed. Yours truly,

R. D. Johnson.

744 Ellicott Square, Buffalo, N. Y., Dec. 26, 1902.

(The note on "A Southern Water Power Development," on the Chattahoochee River, near Atlanta, Ga., appeared on p. 389 of our issue of Nov. 13; the note to which our present correspondent refers appeared on p. 524 of our issue of Dec. 18, 1902.—Ed.)

The Fire on the Tower of the New East River Bridge.

Sir: In view of the fact that an assumption made in my report on the damage done by fire to the New East River Bridge, which you published on p. 411 of your issue of Nov. 13 has misled some engineers, I desire to submit the following explanation: In order to allay great anxiety in the public mind, produced by the unwarranted and exaggerated estimates of damage published by the daily press, I based my calculations of loss of strength of the cables on an assumption "that two layers of wire had been weakened about 15%." At the time I was aware that a short length of the outer layer of wire in the saddles in two cables had been changed to such an extent that the material at that point could no longer be considered "wire," but was more like that classified as "rods." The second layer had been heated to an extent sufficient to cause slight oxidation. The third layer, however, had not been oxidized.

The outer top layers showed for a length of about 5 ft. a peculiar heavy red rust with some white dust or ashes, peculiar to iron heated to more than 1,000°, and producing a loss of strength of about 50% in the wire. The second layer was injured much less, and the strength of the third layer had hardly been affected at all. As the spaces between the wires were filled with a highly carbonaceous material used to prevent corrosion, the incineration of this material produced carbon and ashes, which protected the lower wires against the heat to some extent.

I might here repeat that this slight damage to some of the wires in two cables can be easily repaired by splicing short pieces of new wire in place of the injured lengths. The cost of these repairs and of those necessary in straightening some bent flanges of tower braces, as well as replacing a few suspender stirrups, will not reach $2,000. The principal loss falls on the contractors, who have been compelled to remove the footbridges destroyed and replace them by others, one pair for each cable from anchorage to anchorage.

The most interesting point about what at first was made to appear as a great calamity is this: The com-

plete destruction and rapid removal of the original footbridges by the fire has actually proved a benefit. The beginning of erection of the superstructure has been advanced thereby at least one month or perhaps two, which would have been necessary to remove the footbridges had the work been done by a less heroic method.

Yours truly, Gus. C. Henning.

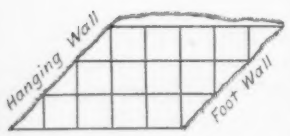
220 Broadway, New York, Dec. 22, 1902.

n Estimating the Per Ton Cost of Mine Timbering.

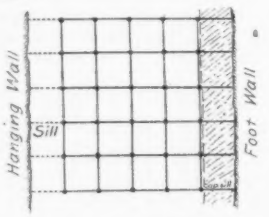
Sir: If you will grant me space I would like to say something more in regard to cost of mine timbering by the square set method, and also make some observations on Mr. MacDonald's reply to my criticism.

In the first place I wish to confess to the truth of his charge in respect to my age, but I trust that no one will think that I am criticising because I wish to pose as a critic.

In his reply Mr. MacDonald said, that in a vein that dips exactly 45°, his statement "That one cap, one post, and one girt or tie makes a set," is true. Granting that the walls of a vein as found are a perfect plane, there would still be quite a discrepancy between that statement and the truth, especially where the stope is relatively wide in relation to the length, as an examination of the accompanying sketches will show.



Vertical Cross Section.



Plan of Sill Floor.

Assume the walls as inclined at exactly 45° and the stope as four full sets wide and five sets long, then across the vein there will be five full sets of excavation in each row and five sets in length, making 25 sets in all, counting the one-half set at each wall. Now by a glance at the accompanying sketch, it is evident that there are 20 posts, 30 caps and 25 girts, provided the cap sills are all resting on the rock, as is usually the case. Then, for each floor of this stope, there are ten more pieces than there are sets, which would affect the per ton cost by several cents.

In the mines of the Black Hills the cost of lagging or lumber of some description to make the floor on top of each set is also quite an item in figuring costs, as very little of the flooring is recovered for use again.

Now it is true that, as the stope shown above increases in length, the ratio of sets to posts increases, but never reaches unity unless the stope also ends with cap sills.

There may be veins as regular as the ones cited by Mr. MacDonald (my personal experience is confined principally to the Black Hills), but judging from the veins here and the description of others in various parts of the world, it would be difficult to find a vein with walls so regular that it would not be necessary to support a number of the cap sills by posts either full length or half; and in a good many places the hanging wall would be so irregular as to require full sets next to the wall. In both cases the excavation would be increased 50% for that set and the full quota of timber would be required.

It seems to me that the proper method to pursue in determining the per ton cost for any method of timbering is to actually count the pieces of timber that are used in the stope, either as it is being transported to the stope or after it is in place, then, taking the sawmill lengths that are required to make these pieces, get the total length or B. M. of each class of lumber. Divide this by the number of tons of ore mined out, and you will then have a fair estimate of the number of feet of lumber used per ton, not counting breakage. If this is done for a number of stopes of various sizes and various degrees of irregularity the average will be a safe figure to use to figure the cost of any future work.

The problem is really not one of how many pieces make a set, but of how many feet of timber is actually used during the life of the stope or until the stope is finished and filled or abandoned. Very respectfully,

B. C. Yates.

Lead, South Dakota, Dec. 20, 1902.

Compensation of Engineers.

Sir: A few weeks ago, "L. C. H." made some comparisons between engineers and doctors, dividing his discourse into "cases." Under case I, he says: "The doctor will throw up the job if another doctor is called in." That isn't so. The attending doctor invariably calls in another just before the patient dies, to divide the responsibility—and increase the expense to the survivors.

However, the great advantage of the doctor over the engineer is that he can get his bad work "under ground," and never have it rise up to haunt him, while the engineer cannot. Yours truly,

A. T. E.

Minneapolis, Minn., Dec. 18, 1902.

There is one thing above all others that must strike the reader of Mr. Himes' article in the Dec. 25, 1902, number of Engineering News, and that is the inadequate compensation received by civil engineers. One would judge, to use the vernacular of the day, civil engineers to be a lot of "cheap guys."

Mr. Himes asks: "What railroad company would think of getting for a $2,500 salary a chief engineer to carry out works costing more than $20,000,000?"

In reply to this I would like to make the most emphatic assertion that there are more chief engineers of railroad companies whose salary is less than $2,500 a year than there are with larger salaries. In fact it is notorious that the employees of the engineering department of a railroad are the most poorly paid of all.

This applies as well to the construction as to the maintenance department. The chief engineer of a railroad company, so far as ability is concerned, should rank at least with the general manager, and perhaps does so in every respect except in salary, that of the latter being generally three, four, and even ten times that of the chief engineer.

On construction we find the same disparity of wages, the contractor's *walking boss* getting more wages than the engineer in charge of a great deal more of work.

Mr. S. Whinery, in the Dec. 26, 1902, number of the "Railroad Gazette," mentions an engineer who built in one case an 18-ft. arch culvert, and in another a 16-ft. arch culvert, where a 10-ft. arch would have sufficed, and states that several thousand dollars were thus wasted. Should this happen, say, once every mile in a railroad 100 miles long we would have an enormous waste of money running into hundreds of thousands of dollars. Of course it might be said that errors of judgment are as likely to occur with a $1,000 man as with one getting $10,000.

So far as chances for promotion are concerned any young man of ability certainly makes a mistake to enter the engineering department of a railroad.

Take the names of the leading officials of our railroads and it will be found that 90% or more have risen from positions such as brakemen, locomotive engineers, clerks, telegraphers, etc.

The most that a civil engineer can expect is to become a division engineer or something of that kind at a salary less than that received by the average locomotive runner.

The same thing is apparent in municipal governments. One example is a certain board of public works consisting of three members, each drawing a salary of $5,000, while the city engineer is getting $250 a month and doing all the work.

A close examination of the salary list of any city, county or state will disclose the sorry fact that, so far as pay is concerned, the civil engineer is generally at the foot. What the remedy for this state of affairs is I must leave to more competent persons than I to suggest.

Respectfully,

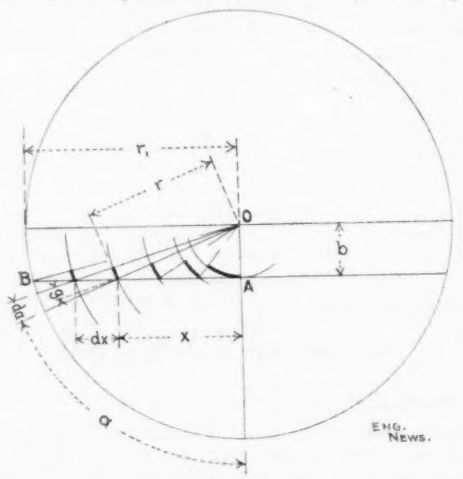
Civil Engineer.

New York, Dec. 27, 1902.

Stresses in a Circular Plate Subjected to Uniform Fluid Pressure and Supported Around the Circumference.

Sir: Let p be the external pressure per sq. in., and r_1 the radius of the plate.

Then the total pressure on the circle is $\pi r_1^2 p$, distributed uniformly around the circumference, whose length



Stresses in a Circular Plate Subjected to Fluid Pressure.

is $2\pi r_1$, and the pressure per lineal inch on the circumference is,

$$\frac{\pi r_1^2 p}{2\pi r_1} = \tfrac{1}{2} r_1 p. \qquad (1)$$

Now, consider an indefinitely narrow strip of the circle, with parallel sides, one of which coincides with the diameter of the circle, the width of the strip being b.

Then the total external pressure upon the strip is $2 r_1 b p$, but the two reactions at the end of the strip support a weight of

$$r_1 b p. \qquad (2)$$

Showing that the strip as a beam carries only half of the total pressure to its reactions, the rest being supported by vertical shears at the side of the strip.

Now as the surface is one of revolution it is easy to see that no vertical shear exists across radial lines as there is no tendency for one sector of the plate to sink beyond another.

The vertical shear operates across concentric circles shown in figure.

Taking our independent variable x from point A toward B; from points along A B, draw arcs of circles centering at O.

The sides of the strip may now be considered bounded by saw-teeth, one face being a radial line across which no shear is transmitted, and the other face being the arc of one of the concentric circles transmitting vertical shear. The unit shear along the arc g is, as with the large circle, $\frac{1}{2} r p$.

The whole amount of shear in the length dx is

$$\tfrac{1}{2} r p \text{ times arc } g. \qquad (3)$$

But,

$$g = r\, d\alpha, \qquad \alpha = \tan^{-1}\frac{x}{b}, \qquad d\alpha = \frac{b\, dx}{b^2 + x^2}. \qquad (5)$$

Then the differential shear along the side of strip is,

$$dw = \tfrac{1}{2} p \frac{b r^2 dx}{b^2 + x^2}. \qquad (6)$$

But $b^2 + x^2 = r^2$. Therefore

$$dw = \tfrac{1}{2} p\, b\, dx; \qquad (7)$$

$$\begin{cases} +r_1 \\ w = p\, b\, r_1, \\ -r_1 \end{cases} \qquad (8)$$

which makes up the support which was lacking at the reactions.

Equation (7) shows that the strip may be considered as a simple beam loaded uniformly with p b per lineal inch and supported uniformly by $\frac{1}{2} p b$ per lineal inch, or simply loaded uniformly with $\frac{1}{2} p b$ per lineal inch. The maximum bending moment will be at the center and equal to

$$M = \tfrac{1}{4} p\, b\, r_1^2. \qquad (9)$$

If d is the thickness of the plate the apparent stresses at the surfaces will be

$$S = \frac{6 M}{b d^2} = \tfrac{3}{2} \frac{p b r_1^2}{b d^2} = \tfrac{3}{2} p \frac{r_1^2}{d^2}. \qquad (10)$$

This stress is affected by an equal stress acting at right angles to it so that if we call Poissons' ratio of lateral contraction $\frac{1}{m}$, the true stress at the tensile side is

$$T = S - \tfrac{1}{3} S = \tfrac{2}{3} S;$$

$$T = \tfrac{2}{3} \times \tfrac{3}{2} p \frac{r_1^2}{d^2} = p \frac{r_1^2}{d^2};$$

which is suggested for a practical formula.

In this discussion the effect of horizontal shears is neglected as it is slight and on the side of safety.

H. S. Richmond,

Thayer School of Civil Engineering.

Hanover, N. H., Nov. 20, 1902.

A Proper Administration for Canal Construction in New York.

Sir: Mr. Himes in his letter and your editorial thereon in the last issue of the Engineering News very properly and pertinently call attention to the fact that as at present organized and the business conducted, the departments presided over by the State Engineer and the Superintendent of Public Works are incapable of properly, efficiently and economically carrying out the work of canal improvement required in the expenditure of $80,000,000 and more for the construction of the 1,000-ton barge canal.

There are probably few more glaring records of administrative imbecility and failure than that displayed in carrying on the $9,000,000 work, and this undoubtedly was largely due to the system under which it was done; a dual system with an inexperienced engineer as one head and an untrained man as the other, totally unacquainted with and absolutely unfit to handle a work of such magnitude. That their work should cause grave dissatisfaction and scandal was inevitable from the beginning.

The present system apparently works fairly well for the ordinary routine of caring for the canals, making minor repairs, additions and changes, collecting statistics, etc., but as conclusively proven, it is wholly unsuited to the great enlargement proposed.

It has long been recognized by the friends and advocates of canal enlargement that when this work should be undertaken it would be a matter of prime importance to effect and provide a thoroughly business like organization of the work, which should command the confidence of the people of the State, and be able to carry the work through to completion in an honest, efficient and economical manner.

With this end in view, and at the request of the Canal Association of Greater New York, Mr. A. E. Blackmar, the able attorney for the Clinton Canal Investigating Commission, and myself undertook to formulate an organization that would accomplish the object sought in the greatest degree possible, and I am going to communicate to you the result of our labors in this particular field, as it is a timely matter of great importance and of particular interest to the engineering world.

Naturally the first thought was that it would be best to do this great work through the medium of a commission, as suggested by Engineering News in its last issue, and as now so commonly done in large works of similar character. Unfortunately, however, this is impracticable, as the Constitution of the State specifically devolves all such work as the repair and improvement of the canals upon the Superintendent of Public Works, except such as may be imposed by law upon the State Engineer. Legislation cannot take away from these officers the burden and responsibility of the work. One or the other, or both, must be the official head or heads charged with it. Upon whom should the responsibility be fixed? Every consideration of propriety and prudence demands that it devolve upon the State Engineer to the greatest extent practicable. This is an engineering work, it was suggested by engineers, its advantages were worked out and shown by engineers, the surveys, plans and estimates were made by engineers, the specifications for the work must be made by engineers, and the quality and quantity of work done must be determined by engineers, whether the legal head of operations be the State Engineer or the Superintendent of Public Works.

Justice, as well as safety and the interests of the State, demand that the work should have behind it all the prestige and esprit du corps of the engineering profession and that there should be no divided responsibility.

The present relations between the offices of the State Engineer and the Superintendent of Public Works, so well described by Mr. Himes are established by law, and while a new law cannot take the work away from both these officers, it can practically fix the entire responsibility for the conduct of the work upon one of them, and it was therefore proposed that in the law providing for the canal enlargement there should be the necessary provision for making the State Engineer the responsible head of the work, utilizing the Superintendent of Public Works for such minor duties as might properly devolve upon him, but which would in no wise relieve the State Engineer from any responsibility for the conduct of the work.

But, as well stated by Mr. Himes, the State Engineer is a very busy man, with a great deal of work on his hands besides this canal business, and he could not possibly devote the time necessary to look after it in all its details, even if a man of great ability, like the present most efficient occupant of the office, Mr. Bond. And the contingencies of politics might throw into the office an inexperienced, inefficient man, or one who from some professional, mental or moral obliquity was unable to properly safeguard and conduct the work. To render the necessary aid to the State Engineer and provide for all contingencies it was proposed by us that a board of five expert civil engineers should be appointed by the Governor as a consulting, supervisory and advisory board, which should perform such duties as might be required by the Governor or the State Engineer and make such reports to either of these officers as they might require or the board itself deem desirable or fitting. Such a board, if constituted of the best and most experienced engineers obtainable, would be of incalculable value, and would be fully as good, and perhaps a great deal better, than a mixed commission to have the whole conduct of the work. It is, moreover, attainable under the Constitution, while a commission is not.

The board would prepare or pass upon all detailed plans and specifications, advise the State Engineer upon all points, exercise a careful and detailed supervision over every contract and the carrying out of the work at every point, and visit and advise with the local engineers and inspect and pass upon the work. In this latter respect the board would be of enormous value, for each subordinate engineer, knowing that he was under the eyes of such a board of distinguished engineers, would do his best, upheld by a strong "esprit du corps" or the knowledge that a break on his part might produce a most disastrous effect on his whole after engineering career.

Such a board, if properly constituted, would be free from politics, and from the dictation of anybody, and be only actuated by the idea of doing everything squarely and well and for the honor of the profession, and while it would have no legal control over the State Engineer, it would probably be an extremely rare occurrence when he would not bow to its judgment.

In addition, it was proposed that the State Engineer should have the right to appoint a Special Deputy State Engineer, who would devote his entire time to the work and perform on it all the duties of the State Engineer practicable under the existing Constitution and laws. It was also proposed that the State Engineer should appoint such number of Resident Engineers as he might deem necessary. He would also appoint all Inspectors, and in fact, practically all subordinates connected with the conduct of the work, thus centralizing everything in the way of responsibility in his office and doing away with the large expense of dual inspection and divided responsibility which was fraught with so much evil in the conduct of the $9,000,000 work.

The general plan proposed by Mr. Blackmar and myself may therefore be summarized by saying that it proposes to place the conduct of the work of canal enlargement in the hands of the State Engineer, who should appoint such deputy and resident engineers, inspectors, etc., as might be necessary, with all operations of every kind under the care and supervision of a board of high-class, distinguished, expert engineers.

This means placing the work where it belongs—entirely in the hands of engineers to carry out, and where I hope it will go. If it is so placed, I believe that it will be done so well and in such marked contrast to much of the work of the State, particularly the $9,000,000 work, that it will shed a lustre upon the profession greater than could be attained in almost any other way.

Very respectfully,

Thomas W. Symons,

Major, Corps of Engineers, U. S. Army.

Buffalo, N. Y., Dec. 27, 1902.

(We give space with great pleasure to Major Symons' discussion of this most important subject and heartily agree with him that such a board as he proposes, properly constituted, might be a great aid to the honest and efficient carrying out of canal construction work. On the other hand, we can see also some large opportunities for disagreements and entanglements, and even corruption, in this plan, and we can by no means accept it as the equivalent of placing the work in direct charge of a responsible commission.

Who would be the really responsible head of the work under the plan which Major Symons proposes, the State Engineer or the Advisory Commission? Unquestionably the State Engineer. Under the present law and Constitution his responsibility cannot legally be taken away from him, and it is even doubtful to what extent legislation can take away the powers of the Superintendent of Public Works, in the manner which Major Symons proposes. The advisory commission, which Major Symons suggests, then, while it would be unquestionably a great aid to an honest and capable State Engineer, would have little real power to checkmate the acts of a State Engineer with some "professional, mental or moral obliquity." As Major Symons himself points out, the contingencies of politics during the time the canal work is in progress might throw such a man into the office of State Engineer; and to such a man an "Advisory Commission" without actual power might be a screen for his operations rather than a check upon them.

As we read Major Symons' letter, he approves the plan we have urged of placing the entire responsibility for the work in the hands of a non-partisan expert commission, and his sole objection is that the present Constitution would not permit this.

It seems to us that the real answer to this dilemma is: Amend the Constitution. Other amendments to that instrument must be made anyway before the canal work will be possible; and the chances of their success will be all the better if "an amendment to ensure honest work" were coupled with it. In other words, at the same time you ask the voters of the State to remove the present restrictions upon its debt-incurring powers, ask their approval also of a measure to secure the efficient expenditure of the money it is proposed to borrow.—Ed.)

Construction Work on the Mexican Central Ry. in 1902.

City of Mexico, Dec. 19, 1902.

Sir: The Mexican Central Ry., during the year 1902, constructed 87.86 miles of railroad, as follows:

	Miles.
San Pedro Extension—from San Pedro towards Paredon	40
Panuco Division—from Lecheria towards Sandoval	25
Los Reyes Extension—Tinguindin to Los Reyes	11.80
Rio Verde Branch—to Rio Verde	1.60
Dynamite Spur—from Noe to Colton	6.21
Sulphur Spur—Conejos to the sulphur mines	3.25
Total	87.86

Between San Pedro and Paredon the contractors did $120,000 of work in November, and will do a little more than $100,000 in December. On the Panuco Division the contractors did $47,000 of work in November, and will do a little more than that amount during December.

Work on our line between Tuxpan and Colima is fairly well under way. There will be 14 bridges at barranca crossings, and 13 tunnels aggregating 1,340 lineal meters in length.

The location of our Tampico line is proceeding slowly on account of the roughness of the country. It is 160 kilometers from the City of Mexico to La Cumbre divide, where the line leaves the plateau or table lands of Mexico and descends towards the hot country. Our locating engineers have one line down the hill 60 kilometers; another line has been located 43 kilometers down the hill; and a third party has been making a location from La Cumbre divide, ascending from that divide to another divide 395 meters higher, and have made a location to the old town of Zacualtipan.

Our engineers are locating on 2½% grade compensated, with 6° max. curves. These 6° curves are measured by 20 meter chords, and are equal to 9° curves of 100 ft. chords.

From La Cumbre divide to the foot of the hill in the hot country will require about 90 kilometers of 2½% grade, and a descent of 2,025 meters or 6,581 ft. We have no trouble in obtaining 2½% grade compensated. The country, however, is very rough and broken and will require very heavy work to get down. Yours truly,

Lewis Kingman, Chief Engineer.

City of Mexico, Dec. 19, 1902.

Notes and Queries.

In the article on the Miller signal system in our issue of Dec. 18, the length of line equipped with this system on the Chicago & Eastern Illinois R. R. was given as 3.5 miles (p. 527, 3d column). This should have been 35 miles.

The Pratt & Whitney Co. call our attention to a slight error in our description of their new Thread-Milling Machine, contained in a "Trade Publication" note in the supplement to our issue of Dec. 18. It was there stated that the milling cutters used require a special machine for grinding them. This is not the case; the cutters may be sharpened on ordinary cutter-grinders such as are found in all well-equipped machine shops. The Pratt & Whitney Co. themselves ground the cutters in this way for the past three years, during which time the Thread-Milling Machine has been used in their shops. Recently, however, they have designed and built, and have since used, the special cutter-grinder referred to, which sharpens these particular cutters much more rapidly than the ordinary cutter-grinder.

NOTES FROM THE ENGINEERING SCHOOLS.

COLUMBIA UNIVERSITY.—A feature of the regular course in mechanical engineering is to be the study of automobile and traction engine design.

RENSSELAER POLYTECHNIC INSTITUTE.—The Proudfit Memorial Laboratory was burned December 17. It will be remmembered that the chemical laboratory was destroyed by fire a few months ago. The loss by this last fire is estimated at $10,000. Fortunately the building was not entirely destroyed, and will be completely repaired within three months.

UNIVERSITY OF MICHIGAN.—Among the new courses now open is one in forestry. The course is open only to graduate students, and adds one to two years to the regular undergraduate course of four years. Twenty-three students have decided to take the forestry course.

Mr. Fred. G. Frink, who has been recently appointed instructor in civil engineering, graduated in the class of '86. During 1897 to 1900 he was a member of the faculty of the University of Idaho.

SPONGY (?) GOLD AND ITS RESISTANCE TO AMALGAMATION.

When ores carrying metallic gold show a low yield by amalgamation, the cause ascribed is generally that the gold is coated with something that protects it from contact with the mercury. The gold is said to be "rusty," or the mercury is declared to be "greasy" or lacking in brightness.

May it not be, after all, that there is some other cause?

At the Mexican meeting of the American Institute of Mining Engineers, Mr. Miguel Bustamente, Jr., read a very interesting paper in which he advanced proof to show that part of the gold was in a porous or spongy form, not unlike the well-known spongy platinum.

What led him to this conclusion was the observation that 11% of the mercury used in amalgamation was lost in extracting only 63% of the assay value of the ore.

He examined the gold that had escaped amalgamation and "found it to be in a peculiar state

of aggregation, reminding one strongly of platinum sponge."

He then concluded that the very finely divided sponge and black gold coming in contact with the mercury provoked an energetic electrochemical action. This action would result in decomposing some of the water present, the oxygen entering the pores of the spongy gold, while the hydrogen would combine with the sulphur of the pyrite producing H_2S. Part of this H_2S would attack the mercury producing mercury sulphide, thus explaining the excessive loss of the mercury. That H_2S was produced Mr. Bustamante avers, as its characteristic odor was very noticeable.

Having formed a theory that explained the loss of the mercury, and the low extraction of gold, he began experimenting with a view to secure increased efficiency, with results that it may be well to give in his own words, as follows:

Before devising a process of my own, however, I tried those of Body (1894), B. C. Moloy (1894), and others, without satisfactory results. Finally, after some experiment and change in my first apparatus, I perfected a method by which the loss of mercury was reduced to 0.03%, and the extraction of gold brought up to 95% of the assay-value, while the cost of treatment was lowered until it only amounted to $0.42 per ton for crushing, and $0.19 for amalgamation and the electric current.

At first, this method consisted in reverberatory roasting of the ore and washing abundantly with water, then passing it through the mortars, where is was pulverized and began to amalgamate. The mortars were provided with interior amalgamating-plates, in communication with the poles of a dynamo that produced a current of 150 amperes, 14 volts. The two stamp-batteries discharged into a common channel, in which, side by side, were placed the large amalgamating-plates, one communicating with the positive pole, the other with the negative. This arrangement gave encouraging results; but in view of the energetic decomposition of water which attended it, the electromotive power was diminished by subdividing the amalgamation-plates and uniting them, not in series, but in tension. This produced the much-desired result. The liberation of gases diminished considerably, and the loss of mercury became insignificant.

Similar dispositions were made for the pans and the washers. Over the wooden shoes were placed amalgamating-plates 2 decim. square, and on the side-walls of the buckets similar plates 0.5 m. square, united, in tension with the poles of the dynamos, in such a manner that the electromotive power would not exceed 1.5 volts. Later, the aggregate surface of the plates was enlarged to some 15 m. square, which gave the best results. A further increase of surface would have been useless.

On an average, 9 tons of ore were treated every 24 hours; the extraction of gold was 94%, and the loss of mercury was insignificant. Still later experiments led me to abondon the preliminary roasting of the ore; and this resulted in the maximum gold extraction of 95% of the assay value.

PROGRESS ON THE SIMPLON TUNNEL for the month of November is reported in the "Schweizerische Bauzeitung" as follows: The total advance of the headings was 1,201 ft., of which 633 ft. is to be credited to the heading on the north side of the tunnel and 568 ft. to the south or Iselle heading. The total length to which the headings have been driven up to Dec. 1, 1902, is therefore 27,096 ft. for the Brieg end of the tunnel and 18,739 ft. for the Iselle end, or 45,835 ft. for the entire tunnel. The average number of men employed on the work during November was 3,090, of whom 2,219 worked within the tunnel and 871 men outside. The rock pierced by the headings during November was the same in both ends of the tunnel, a somewhat schistose gneiss rock. The water flowing from the portals measured 1.4 cu. ft. per sec. at the north end, and 34.5 cu. ft. per sec. at the south end.

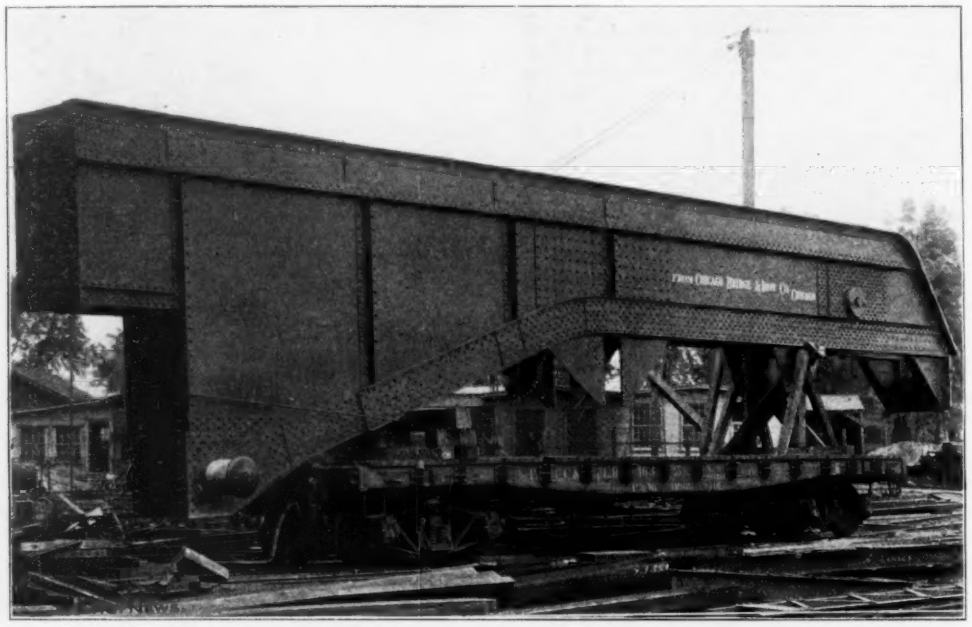


FIG. 1. GIRDER FOR PIVOTED APPROACH SPAN OF ASHLAND AVE. BRIDGE, CHICAGO.
Chicago Bridge & Iron Works, Contractors.

PAGE BASCULE BRIDGE OVER THE CHICAGO RIVER AT ASHLAND AVENUE.

The Page type of bascule bridge adopted by the Sanitary District of Chicago to carry Ashland Ave. over the Chicago River was described and illustrated in our issue of April 25, 1901, but the bridge as built differs materially from the original design.

It was intended to be a through-truss structure with horizontal bottom chords, and trusses 21 ft. deep at the ends. Instead of this, however, a half-through truss design was adopted, with shallow trusses, having the top chord horizontal (about 5 ft. above the floor) and the bottom chord arched. This style of bridge was also illustrated in the article above referred to, but the dimensions differed from those of the Ashland Ave. bridge, which has a channel span of 168 ft. c. to c. of trunnions, and shore spans of 48 ft. The trusses are 7½ ft. deep at the outer ends and 22½ ft. over the trunnions. They are spaced 40 ft. c. to c., and carry a 36-ft. clear roadway and two outside sidewalks, 8 ft. wide in the clear. The 48-ft. approach spans form the counterweights, there being no cast-iron counterweights in the heels of the main trusses. The shore end of the approach span is pivoted over the abutments, while the river end rests on the heel of the main span, so that when the bridge is open the approach spans have a downward inclination. These spans have each two box girders of very heavy construction, and are weighted by solid concrete floors and brick paving. One of these great girders, mounted on a car for shipment, is shown in Fig. 1. Fig. 2 is a view of one leaf during erection, showing also the inclined approach span and the 96-ft. steel boom used in erection. This boom was made in three sections, being lengthened as the work progressed. Fig. 3 shows a view of the completed bridge closed.

Fig. 2. Erecting Ashland Ave. Bascule Bridge, Chicago.

No part of the superstructure extends below the water level when the bridge is either open or closed, and this is one of the special advantages claimed for this type of bascule bridge. The total weight of the iron and steel in the superstructure, including machinery, is about 840 tons. The piers and abutments are of concrete, and aggregate about 2,770 cu. yds.

The operating mechanism is shown in Figs. 4 and 5. The bridge is opened and closed by means of four operating struts, the outer ends of which are attached to pins in the top chords of the trusses, while the inner ends are forked and fitted to trunnions on cast-steel nuts which ride on four long screws placed within the top chords of the approach girders. Each screw is 32 ft. long and 7½ ins. diameter over the thread, which is ¾ × ¾-in. The rear end of the screw runs in a cast-steel thrust block, this block and the nut having phosphor-bronze bushings. To prevent any deflection of the screw when acting as a strut to push the bridge down, a rest is arranged to run in the guide casings which support the nut, and is so placed that when the bridge is closed the block is at about the middle of the screw. Two 38-HP. electric motors are used for each half of the bridge, driving a transverse shaft under the approach span. The motors and shaft are carried by supports attached to the under side of the span. Inclined shafts parallel with the girders extend from the transverse shaft to the screws, being connected to the shaft and screws by bevel gears.

This type of bridge is the invention of Mr. John W. Page, of Chicago, and the designs were prepared and shop drawings made by Mr. W. M. Hughes, M. Am. Soc. C. E., Consulting Engineer, Great Northern Building, Chicago. The substructure work was done by Page & Schnable, and the superstructure (including operating machinery) was built by the Chicago Bridge & Iron Works.

REPORT ON STREET RAILWAY IMPROVEMENTS IN CHICAGO.

The street railway system in Chicago has long been a source of contention between the city authorities, the public and the railway companies, one of the principal points in dispute being the renewal of the franchises. The construction, equipment and operation, however, afford many points for complaint on the part of the city and the public. The main street railway system was until quite recently divided between three separate companies, operating on the north, south and west sides, respectively, and all having terminals in the center of the city. There were no transfers between the lines of different companies, so that a trip from one section of the city to another involved the payment of two fares. The west and north side companies have now been consolidated, and after much opposition the city has secured a comprehensive system of transfers between the various lines operated by the new company, although the company is still contesting the matter in the courts. The dead-end and loop terminals in the down-town district cause serious congestion of traffic, but the companies are

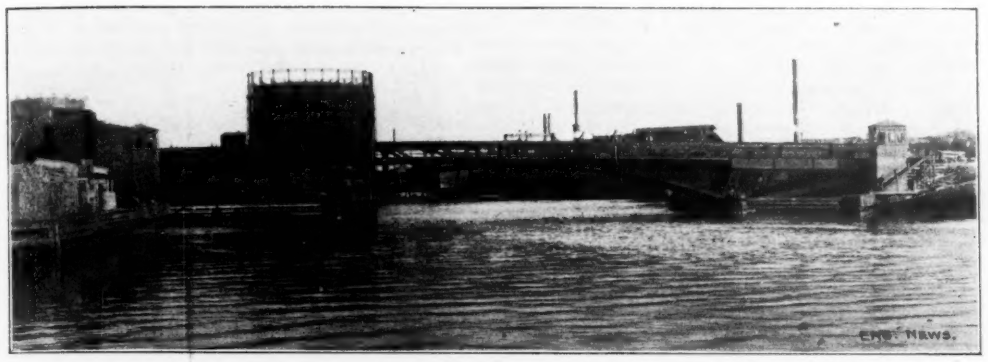


FIG. 3. VIEW OF ASHLAND AVE. BASCULE BRIDGE, CHICAGO.
John W. Page, Inventor; W. M. Hughes, Consulting Engineer.

opposed to the introduction of through routes, and also claim that they cannot make many desired improvements in construction, equipment and service until the city grants them new and liberal franchises. These conditions were noted in our issue of Feb. 13, 1902, and about six months ago the Local Transportation Committee of the City Council appointed Mr. B. J. Arnold, M. Am. Inst. E. E., to investigate the technical matters involved. This was noted in our issue of June 5, 1902, and we are now indebted to Mr. Arnold for a copy of his preliminary report, which is practically a summary or digest of the main report, which will be issued shortly and will (with its appendices) form a large volume.

With this general explanation of the conditions which now exist, and which have given rise to the present investigation, we give the following abstract of the preliminary report and its conclusions:

I have not assumed it my place to take sides in the report on questions of municipal policy concerning which there may be differences of opinion, except where the questions are in their nature clearly engineering or transportation questions. The franchise policy of the city with reference to these matters I have conceived to be outside of my province. The plans for a comprehensive system of street railways suited to the needs of the community as set forth in the report would be the same whether the system be owned and operated by a private corporation or owned and operated by the city or owned by the city and operated by a private corporation under lease. So far as engineering features alone are concerned, it is immaterial whether the subway systems as outlined be owned by the city or by a private corporation.

In connection with my investigation of this problem I have considered many plans, such as movable sidewalks, elevated sidewalks, sub-sidewalk railways, and elevated structures for carrying railways, pedestrians, and the present underground utilities, some of which plans originated with me and some with others. After a careful study of the situation, the magnitude of the problem as evidenced by the great number of passengers which must be taken in and out of the business district in very short periods of time, night and morning, has forced me to abandon some of my preconceived ideas, and it is my opinion that a full realization on the part of others of the exact conditions which must govern a comprehensive solution of this problem would show the advocates of the other plans the inadvisability of their adoption. It is possible, however, that some of the suggestions relating to super-surface structures may some day prove advisable to adopt in Chicago, but probably not until the capacities of the systems recommended in this report, or other similar systems, have been reached.

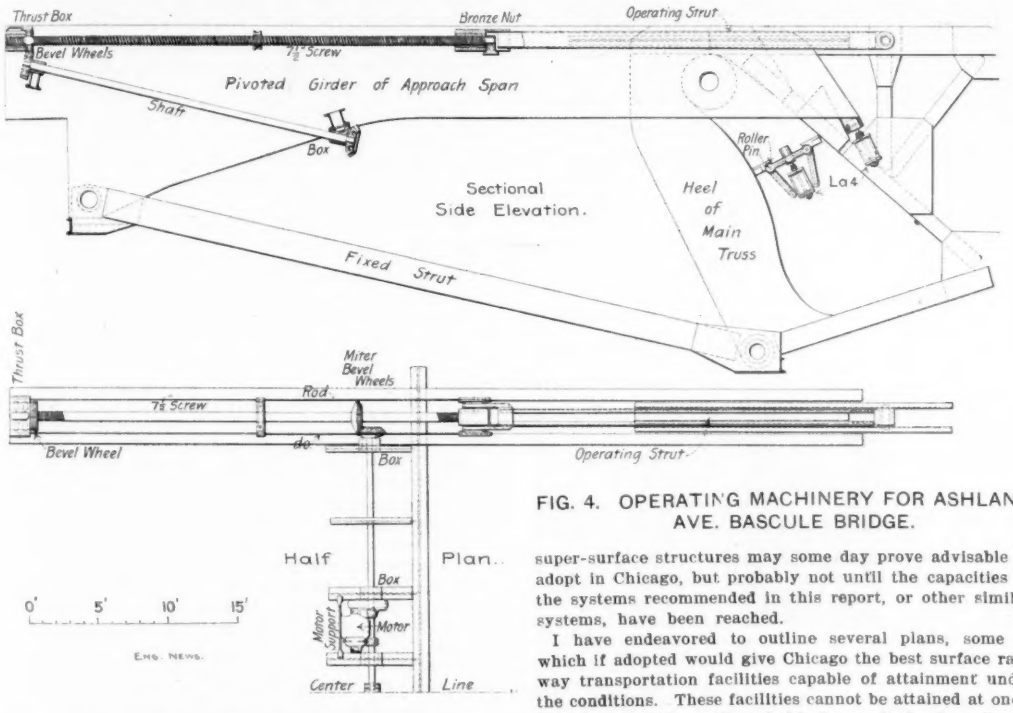


FIG. 4. OPERATING MACHINERY FOR ASHLAND AVE. BASCULE BRIDGE.

I have endeavored to outline several plans, some of which if adopted would give Chicago the best surface railway transportation facilities capable of attainment under the conditions. These facilities cannot be attained at once, and the transition will probably be gradual. In order to make it possible to get immediate relief, a plan of surface tracks which could ultimately become a part of a combined system, has been outlined. This plan provides for ample facilities on the surface for the present needs, permits of through traffic between all divisions with the joint use of tracks, and makes it possible to immediately abandon the river tunnels for street car purposes, thereby permitting the river channel to be immediately deepened for the accommodation of lake traffic, and portions of the tunnels to be still retained for future subway uses.

I trust that the information contained in the report will be found sufficiently exhaustive and of sufficient merit to enable the committee to formulate a line of action which will lead to practical results.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS.

1. THE ONE-CITY-ONE-FARE IDEA.—Chicago, with respect to transportation as well as other things, should be regarded as one city, not three. Divisional lines ought to be obliterated, as far as possible. A street car passenger should be carried over the most direct route between any two points within the city limits for a single fare. Complete unification of ownership and management is the best plan for realizing this. The same end can be accomplished, however, but in a less satisfactory manner, under divisional ownership, by a plan of through routing of cars, joint use of tracks and interchangeable transfers. To a still less satisfactory degree the same end can be accomplished by the interchange of transfers between companies without joint use of tracks.

2. THE THROUGH ROUTE PRINCIPLE.—Routes through the business district ought to be substituted for down-town terminals, wherever possible. Outside the business district, too, the best results would follow from connecting together the detached lines now found on several streets, and operating cars over such lines from end to end on the through route principle.

3. SUBWAYS.—A system of subways should be (and eventually must be), built to accommodate the street car traffic and relieve the street surface congestion in the business district. Galleries should be provided in connection with such subways for the accommodation of present and future underground utilities. Two subway plans are outlined in the report. One plan calls for three north and south subways, from 14th St. on the south to Indiana St. on the north, and two subways entering the business district from the West Side, utilizing the present Van Buren St. and Washington St. tunnels and looping back at Clark St. This is a system of high-level subways throughout, with no dips. Its estimated cost is $16,000,000. The other subway plan calls for practically the same north and south high-level subways in combination with three or more low-level subways from the West Side, pasing under the north and south subways and reaching Michigan Ave., and (should future developments warrant), under Lake Front Park as far as it may be extended. The low-level subways would require the use of elevators. The estimated cost of subways built according to this plan is $20,000,000. The second plan is recommended as best for the city from an engineering and transportation point of view.

No subways should be built in such a manner as to preclude the operation of cars through them on the through route principle. The whole system of subways need not necessarily be constructed at once; one or more could be built at a time, and utilized separately, but with a view to their ultimately forming a part of a comprehensive system. The subway plans as submitted do not necessarily call for the removal of all tracks from the street surface in the business district, and the first plan necessitates some surface loops. Under either plan there could be a street surface system connecting the railway stations and designed to accommodate short-haul traffic in the business district. Under the second plan there could also be a low-level subway system for connecting all stations, and by using it in connection with this subway all tracks could be kept off from the surface of the streets in the business district for some years to come.

4. THE PRESENT RIVER TUNNELS.—It is inadvisable to attempt to lower the present river tunnels and at the same time retain them for surface railway use, for the reason that lowering the tunnels to a sufficient depth to accommodate future river traffic would involve extending the tunnel approaches at least a block further into the business district. In the interest of navigation, therefore, the tops of the tunnels ought to be promptly removed, leaving the lower parts of one or perhaps two of the tun-

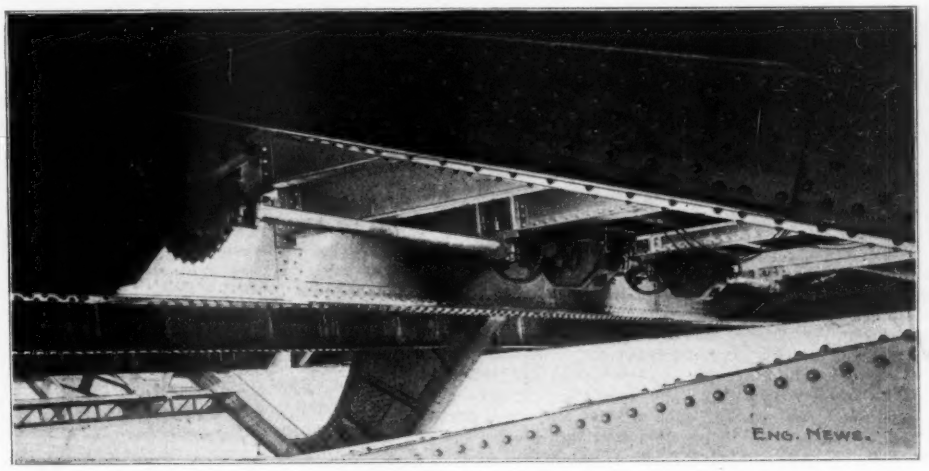


FIG. 5. VIEW OF OPERATING MACHINERY UNDER APPROACH SPAN.

nels for utilization later as parts of a future subway system.

5. COMBINED SURFACE AND SUBWAY STREET RAILWAY SYSTEM.—A plan is presented for a combined surface and subway street railway system, comprising the lines of the City Ry. Co., the Union Traction Co., the Chicago General Ry. Co., and the Chicago Consolidated Traction Co. within the city limits, and new lines necessary to properly connect the now disconnected parts of the system. The total single track mileage of this system as outlined would be about 745 miles, and its estimated cost, if constructed new, with everything first-class throughout, but exclusive of subways, would be $70,000,000. Adding the cost of the subways, the total cost of the new system complete would be $90,000,000 under the first plan, or $85,800,000 under the second plan.

6. PLANS FOR IMMEDIATE IMPROVEMENT OF TERMINALS AND SERVICE.—Plans are presented for the re-routing of surface terminals in the business district, (1) under the present divisional ownership and operation, (2) under the joint use of tracks in the business district under divisional ownership, and (3) under unified ownership and management. Immediate improvement may be effected by substituting electric for cable power and routing cars according to any of the plans outlined, all cars from the West and North sides to enter the business district over bridges until such time as subways shall be constructed.

7. ELECTRIC UNDERGROUND CONDUIT SYSTEM.—The operation of cars in Chicago by the electric underground conduit system is practicable and feasible. Overhead trolley construction should be prohibited within the area bounded by 12th St. on the south and the river on the north and west. Outside of this district the objections to the overhead trolley are esthetic in nature, and it is for the city authorities to say (after a balancing of financial against esthetic considerations) how much, if any, underground conduit construction should be required. The cost per mile of single track (track alone, including feeders,) of electric conduit road construction would average $81,300 for a system covering the entire city, including feeder wire, but exclusive of the cost of power, rolling stock and paving of right of way. All conduit construction, however, within the business district would cost about $100,000 per mile, due to the numerous curves, large amount of special work required and the extra cost of labor, due to the congestion within the district in which the work must be prosecuted. To either of the above figures should be added the cost of paving, as follows: Brick, $12,650; asphalt, $12,880; dressed granite, $18,400. Overhead trolley road construction would cost $20,836 per mile of single track, using the same weight of rail. It would cost nearly as much to convert the Chicago cable roads into electric conduit roads as to build new electric conduit roads.

8. GROOVED RAILS.—A grooved girder type of rail, of special design, is recommended for well-paved streets upon which cars operate often enough to properly clear the groove of dirt and ice. On outlying streets and on poorly paved and poorly maintained streets the girder type of rail should be maintained as best for team traffic and the railway companies.

9. ELECTROLYSIS.—The destruction of underground utilities from electrolysis is now well in hand by the city, and if the present ordinance governing the subject is enforced no serious difficulties may be anticipated from this source. When the underground conduit system is adopted there should be no further injury from electrolysis in the area served by this system, as it uses a complete metallic circuit.

10. THE FINANCIAL ASPECT.—A unified company could afford to conduct the transportation business of Chicago on the basis of a single fare for a continuous ride anywhere within the city limits. The present divisional companies, by the interchange of transfers, could afford to do the same thing, provided they were properly protected against the fraudulent use of transfers, but it would be at a somewhat greater cost to themselves, and with greater inconvenience to passengers than would be the case under unified management.

11. GROWTH OF POPULATION AND TRAFFIC.—The population of Chicago has increased since its incorporation in 1837 to 1902 at the rate of 8.6% per year compounded, and is now increasing at the rate of 7.7% per year. For the nine years from 1892 to 1901 inclusive, the number of revenue passengers carried by the Chicago surface and elevated lines combined has increased at the rate of 5% per annum compounded. The increase for the surface lines during the same period has been at the rate of 1.5% per year compounded. The increase for the combined surface and elevated lines from 1894 to 1901 inclusive, a period of seven years, has been at the rate of 6.3% per year compounded. The increase for the surface lines alone during the same period has been at the rate of 3.9% per year compounded, and the increase for the elevated lines alone has been for the same period at the rate of 2.6% per year compounded. The population of Chicago has increased more rapidly than that of any other city in the world, but it is improbable that this rate of increase should continue indefinitely.

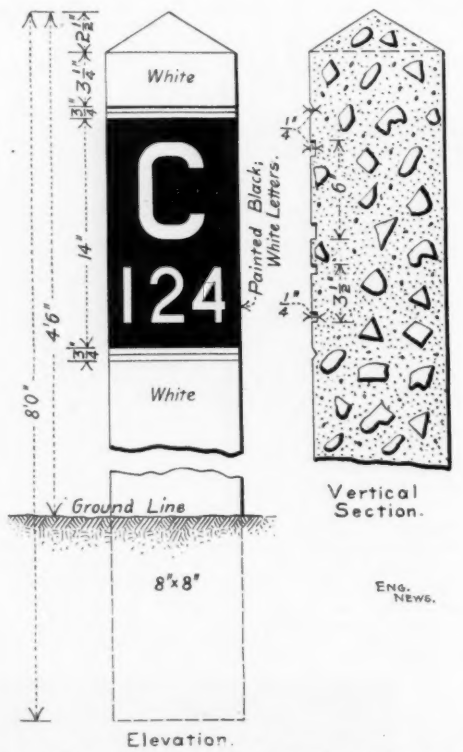
12. ESTIMATED COST OF REPRODUCTION.—The cost to reproduce the following properties complete with new construction and equipment throughout would be as follows: Chicago City Ry. Co., about $17,200,000; Chicago Union Traction Co. (not including the Consolidated Traction Co.), about $22,200,000. The actual present value of the physical properties for railway purposes of the following companies, taking into consideration the obsolete equipment and construction which must be discarded, but not taking into account any franchise rights or earning capacity of the properties, is estimated as follows: Chicago City Ry. Co., about $12,000,000; Chicago Union Traction Co. (not including Consolidated Traction Co.), about $15,000,000.

13. REGULATION OF TEAM TRAFFIC.—At the present time team traffic interferes with street cars to an unwarrantable extent. A reasonable regulation of team traffic is essential to the improvement of street car service.

14. THE UNION ELEVATED LOOP PROBLEM.—The junction points are the ultimate limiting factor of the capacity of the Union Elevated Loop. At the present time, however, the station platforms are the limiting factor. The first and simplest way to increase the capacity of the loop is to lengthen the platforms so that two trains can load and unload at a station at the same time. When the capacity of the junction points is reached, added facilities can be provided by building stub-end terminals just outside the loop. The terminal capacity of the loop could be increased by dividing the present loop into four smaller loops, but presumably there would be public objection to such a plan, because it would involve encumbering more down-town streets with elevated structures, and it is, therefore, not recommended. The ideal solution of the elevated loop problem would be utilize the loop structure as sections of through routes between the different sections of the city.

CONCRETE MILE POST; CHICAGO & EASTERN ILLINOIS R. R.

An interesting example of the varied purposes to which concrete is now being adopted is afforded by the use of concrete mile posts on the Chicago & Eastern Illinois R. R. A special feature of these posts is that the face is blackened by coloring



Concrete Mile Post; Chicago & Eastern Illinois R. R. A. S. Markley, Superintendent of Bridges and Buildings.

matter added to the concrete, so that the only expense for maintenance is the occasional painting of the white figures, and as these are recessed, the work can be easily done by unskilled labor.

The style of post is shown in the accompanying cut. It is 8 × 8 ins., 8 ft. long, with 4 ft. 6 ins. above ground. The weight is 498 lbs. They are only made when other concrete work is being done, and only one form is used, the figures being movable. The form is laid with the letters on the bottom, and the sides are plastered to a thickness of ½-in. before the ordinary concrete is put in. This is to make a smooth surface for the exposed part of the post. The two recesses across the face of the post are formed by strips which separate the black face concrete of the lettered panel from the white concrete above and below. After the concrete has thoroughly set the letter and figures are painted white. The concrete is composed of 1 part cement, 1 part sand and 2 parts crushed stone. The black face concrete is colored with ¼-lb. of lamp black mixed with 1 quart of cement in water. The cost of the post is as follows:

¼ barrel of cement, at $2	50 cts.
267 lbs. of crushed stone	1 "
133 lbs. of sand	1 "
1⅓ hours of labor at 15 cts.	20 "
Carpenter changing letters, ½ hour at 25 cts.	8 "
Coloring cement	2 "
Total	82 cts.

For the above information we are indebted to Mr. A. S. Markley, Superintendent of Bridges and Buildings of the Chicago & Eastern Illinois R. R., Danville, Ill.

GERMAN FUEL BRIQUETTE MACHINERY FOR AMERICA

There is in America a vast amount of powdered carbon in the form of culm from anthracite breakers, slack from bituminous mines, and peat or lignite too friable to be of use in its natural state, if it is attempted to burn it in an ordinary furnace.

It is true that experiments are being made to burn powdered fuel by blowing it into the firebox with air under pressure. Whether commercial success will follow attempts along this line remains to be seen; but in Germany and France where good fuel is high-priced, it has been found profitable to briquette powdered fuels.

With the gradual exhaustion of our best coal mines the time is surely coming when it will pay to utilize what is now a waste product—the coal dust; and it may even pay to use the inferior lignites and peat.

At any rate it is interesting to note that the Germans are preparing to invade America with their briquetting machinery, showing that they believe that there will be a demand for their machinery in the immediate future.

From a recent report of Mr. Frank H. Mason, Consul-General, at Berlin, we have abstracted the following:

There is no reason why any American operator or mine owner should risk a dollar in vague or hazardous experiments; he has only to ascertain by expert inquiry what his crude material contains; whether or not it is adapted to profitable conversion into briquettes, and, if so, by what processes and machinery it can be most effectively treated. With a view of answering concisely the latest inquiries on this subject and simplifying to some extent the practical proposition, the following resume of the briquette manufacture as it exists in Germany is submitted.

German briquette factories are divided, in respect to the crude material employed, into two general groups—those which make household briquettes from brown coal (lignite) or carbonized peat, and those which produce the so-called "industrie briquettes," using as basic material coal dust or "slack," the waste of bituminous coal mines.

Household briquettes, as made in Germany from brown coal, peat, and to a small extent from anthracite dust, are used for grates, heating stoves, cooking stoves and ranges, and constitute the principal household fuel of Berlin and other German cities. They are clean to touch, kindle readily, burn with a clear, full flame, and are cheaper in Berlin, ton for ton, than anthracite or good bituminous coal. They are made, largely from brown coal, in factories located mainly in Silesia, Saxony and the Rhine provinces, and united in a syndicate, which controls the output, regulates prices, and looks after the general welfare of the industry.

Machinery for the manufacture of briquettes from lignite is made by several large establishments, among which may be cited the Zeitzer Eisengiesserei, at Zeitz, in Saxony; the Maschinen Fabrik Buckau, in Madgeburg, and the Konigin Marienhutte, at Cainsdorf, in Saxony.

There are in Germany 439 brown-coal mines, which produced last year 44,211,902 tons of lignite, valued at $46,042,500, or a little more than $1 per ton. Of this whole number of mines, 181 have each from one to six briquette factories, in each of which from one to ten presses are employed. The whole brown-coal briquette industry of Germany includes 286 factories, with a total of 691 presses. Statistics of the total yearly product are not accessible, but from the fact that a single press turns out from 50 to 90 tons per day, it will be readily inferred that the annual output is enormous. They are the standard household fuel throughout a large portion of this country, and are besides largely used for firing steam boilers, especially in cities, where their cleanliness and freedom from smoke and dust are highly esteemed. The

standard household briquette is about 8 ins. in length by 4 ins. in width and 2 ins. thick, and is retailed and delivered in Berlin at prices ranging from $2 per 1,000 in summer to $2.50 in winter.

Industrial briquettes are used in Germany for firing locomotives and other steam boilers, for smelting in reverberatory furnaces, and for many other kinds of industrial heating. They are made of bituminous coal dust, held together by a matrix of mineral pitch—that is, coal tar derived from retort coke ovens or gas manufacture, and from which the benzole and other valuable elements have been eliminated. Pitch of this quality costs in this country from $10 to $12 per metric ton (2,205 lbs.). The percentage of matrix necessary to be used varies greatly with the "fatness"—i. e., richness in bituminous elements of the coal itself. Slack from very fat coal will work into briquettes with an addition of 2 to 3% of pitch, while leaner grades may require 6 to 8 or even 10%, the latter proportion being sufficient, at the present cost of pitch, to render such coal unprofitable for briquette-making purposes. Briquettes made from bituminous slack, although not smokeless, are much more nearly so than ordinary bituminous coal. When burned in locomotives or any well-constructed boiler or other furnace with a good draft, they create only a thin, translucent mist, which contains relatively little soot, and is very different from the inky clouds that roll up from most factory chimneys where soft coal is shoveled indiscriminately into the furnaces. The one notable defect of such briquettes is that the mineral pitch, which is used as a binder, contains more or less creosote; this renders dust and fumes from such fuel acrid and sometimes irritating to the skin when confined in a close, hot boiler room. Soft-coal briquettes are made from the dust and waste of mines, and, when the composition of the coal is such as to permit a low percentage of binder to be used, they are the cheapest and easiest kind of briquettes to produce. They are made in machine presses with a capacity of 90 tons of briquettes per day.

The output of soft-coal briquettes in western Germany is controlled by a syndicate called the Briquette Sale Syndicate of Dortmund, which includes among its members 31 factories, located in Westphalia and the Rhine provinces. These establishments employ, collectively, 112 machine presses of the Couffinhal type, besides one French machine of the Bourriez model and three so-called "egg-rollers," or machines, which produce small, oval briquettes of egg size, which are burned in certain kinds of tubular boilers. The syndicate claims a maximum annual capacity of 2,100,000 tons, and, as its official report shows, makes about three-fourths of that amount—whatever the market will take at prices which the syndicate managers consider equitable. Industrial briquettes are usually of a square or oblong form, convenient to be closely packed or built up into a wall, like bricks, whereby they greatly economize space as compared with raw coal. They range in weight from 3 to 10 lbs., and each bears the initials or trade mark of the company by which it is produced, so that in case of any defect in quality the inferior briquette can be readily traced to its source of production. When burned whole, they are consumed slowly and give out a steady, moderate heat for a long time; when it is desired to quicken or intensify the flame, they are broken up, and in this condition are especially adapted to flue or tubular boilers, sugar evaporating, smelting and annealing furnaces, in glass manufacture, or in porcelain and cement factories, wherever, in fact, a fuel capable of producing a long, fierce flame is desirable. Their efficiency as locomotive fuel may be inferred from the fact that the State railways of Prussia, which used 130,000 tons of such fuel in 1889, have bought from the syndicate 680,000 tons during the first nine months of 1902.

Anthracite coal is so sparingly produced in Germany that the use of hard-coal dust for briquette making is relatively unimportant. Experts, however, agree that with an admixture of from 4 to 8% of matrix, the manufacture of anthracite briquettes, which will bear transportation by sea or land in any climate, presents no technical difficulty.

As has been indicated in previous reports, the manufacture of coke and briquettes from peat or turf is still relatively in the experimental stage, although there are several factories in successful operation, and another (largest of all) is just being put into operation at Konigsburg, on the Baltic Coast of East Prussia.

As a result of the present widespread interest in this subject and the many inquiries that have been received from mine owners and operators for technical information as to processes, cost and capacity of machinery, etc., a combination has been formed between three of the foremost machine builders in this country, whose products collectively include all the necessary apparatus for making briquettes from coal dust, brown coal and peat. The purpose of this syndicate is to meet promptly and efficiently the American demand for machinery and working methods which represent the best results obtained by scientific study and mature experience in Germany. The combination is entitled "The Export Syndicate of Briquette Machinery Manufacturers," with central office at No. 59 Friedrich Strasse, Berlin, and includes as members the Zeitzer Eisengiesserei at Zeitz, Saxony; the Maschinenfabrik Buckau at Magdeburg, and the Maschinenfabrik (formerly Jaeger) at Ehrenfeld-Cologne. Its plan is to send over, within a few weeks, an experienced engineer, who will establish an office at New York and be prepared to confer with firms and persons who contemplate entering upon the manufacture of briquettes, to examine sites and materials, make plans and estimates for buildings, machinery, etc. An opportunity will be thus offered for American mine owners and operators to ascertain definitely in advance the theoretic value of their materials for briquette making, and the cost of a plant of a given daily capacity.

Meanwhile, the same results can be reached with important saving of time if owners of coal mines of lignite beds will send to the above address, directly, or through this consulate, 10-lb. samples of their material in the exact condition in which it will be available in large quantities for practical use. The percentage of water in any briquette material is an important factor in determining how it can best be worked.

If the material is dry—as, for instance, slack from a well-drained bituminous coal mine—the sample may be sent in an ordinary box or package. If, on the other hand, the slack or culm is obtained wet from a washing process, or if the material is lignite or peat from a bog, the sample should be sent in a tight tin case, which will preserve the exact percentage of moisture which will be encountered when it is mined for use on an industrial scale.

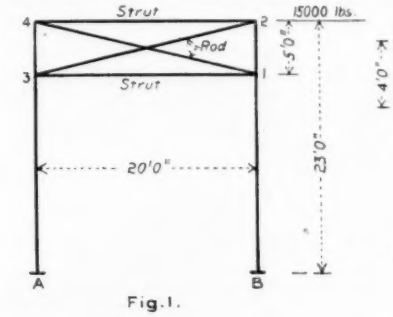


Fig. 1.

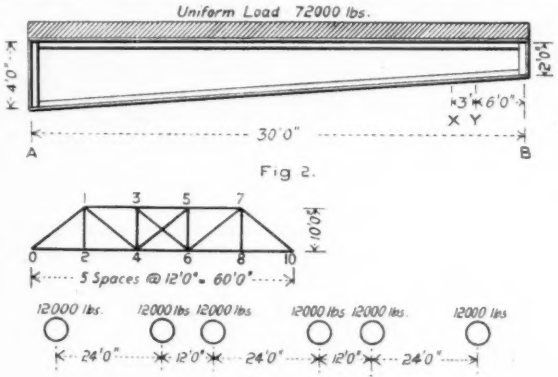


Fig. 2.

Fig. 3.

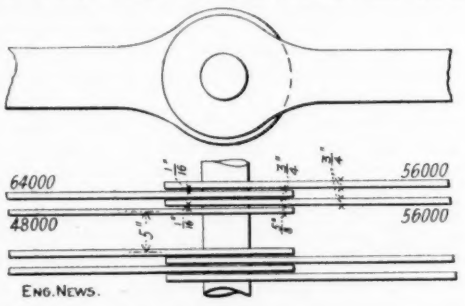


Fig. 4.

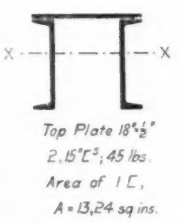


Fig. 5.

ENG NEWS.

We may add that the recent anthracite coal strike has aroused an interest in substitutes for anthracite that never before existed; and it seems likely that workers on the fuel production problem will turn their attention to the processes of fuel briquetting which have met with so much success in Europe.

CIVIL SERVICE EXAMINATION FOR STRUCTURAL IRON DESIGNERS AT CHICAGO.

An examination for structural iron designers was held Dec. 10 by the Civil Service Commission, of Chicago, and through the courtesy of Mr. T. J. Corcoran, Secretary of the Commission, we are enabled to give the list of questions submitted to the competitors. A notice of the examination was published in our columns, and we are informed that through this notice inquiries were received from New York city, Buffalo, Boston, Philadelphia, Pittsburg and other points:

EXAMINATION QUESTIONS.

MATHEMATICS.

1. What would be the weight of a solid column 10 ft. long and 9 ins. diameter if made of (A) cast iron; (B) wrought iron; (C) steel.
2. What should be the area in cross section of a steel strut 1 ft. long that is to carry a load of 10 tons with a factor of safety of 4.
3. How many feet B. M. (A) in a floor 10 ft. wide by 120 ft. long made of 3-in. oak planks; (B) In an oak timber 6 × 14 ins. and 18 ft. long.
4. What should be the diameter of a wrought iron rod which is to stand a tensile strain of 7,000 lbs. with a factor of safety of 7.
5. What is the moment of inertia of a box girder 7 ins. square outside measurement and made of metal ½-in. thick.

DUTIES.

1. In braced portal, Fig. 1, find reactions and strains in rods.
2. In plate girder, Fig. 2, find spacing of rivets for a distance of 4 ft. from end "A"; also spacing of rivets between points X and Y. Allow 3,500 lbs. bearing and 3,000 lbs. for single shear per rivet.
3. In pony truss, Fig. 3, find maximum strain in members 1-3 and 1-4 for loads, as per diagram, moving over bridge.
4. In the same pony truss, what are the strains in members 3-4, 5-6, 3-6 and 5-4 for a panel dead load of 5,000 lbs. when both diagonals are stiff members.
5. Find maximum bending moment on pins shown in Fig. 4.
6. In section shown in Fig. 5, find the radius of gyration around axis X-X correct to two decimals.
7. Find section modulus "S" of section shown in Fig. 5.
8. In sidewalk bracket, Fig. 6, find the strain in member A-B.
9. Find the number of rivets required for member A-B in sidewalk bracket, Fig. 6. Member composed of two angles. Allow 3,500 lbs. bearing and 3,000 lbs. for single shear per rivet.
10. Find deflection at center of beam shown in Fig. 7.

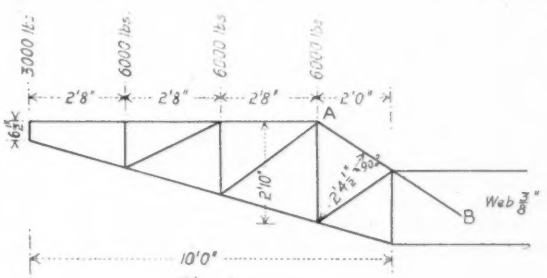
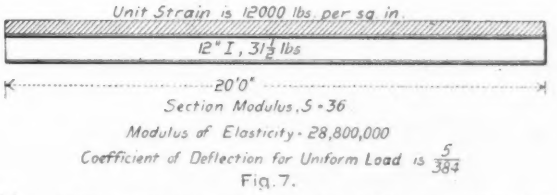


Fig. 6.


Unit Strain is 12000 lbs. per sq. in.
12" I, 31⅓ lbs
20'0"
Section Modulus, S = 36
Modulus of Elasticity = 28,800,000
Coefficient of Deflection for Uniform Load is 5/384
Fig. 7.

THE NEW YORK RAPID TRANSIT RAILWAY.

XV.

Contract Section VIII.

Contract Section VIII. of the Rapid Transit Railway extended from the center line of 110th St. to 100 ft. north of 135th St., and ran underneath Lenox Ave. for the whole distance. The contractors for the section were Farrell, Hopper & Co., Farrell & Hopper doing the construction from 110th St. to 175 ft. south of 116th St., and Mr. John C. Rodgers doing it from that point to 100 ft. north of 135th St.

SUBWAY STRUCTURE.—The railway structure through Section VIII. is the two-track subway construction with a single turnout between

133d and 138th Sts. It is located on the west side of the avenue, between the curb line and the adjacent street railway track, and parallel to the center line of the street. The grade is nearly level, and the depth of the top of the structure below the street surface is seldom over 2 ft. There are four stations, located, respectively, at 110th, 116th, 125th and 135th streets.

MATERIALS PENETRATED.—The subsurface material along the line of the subway from 110th to 135th St. was mostly loose soil, composed of

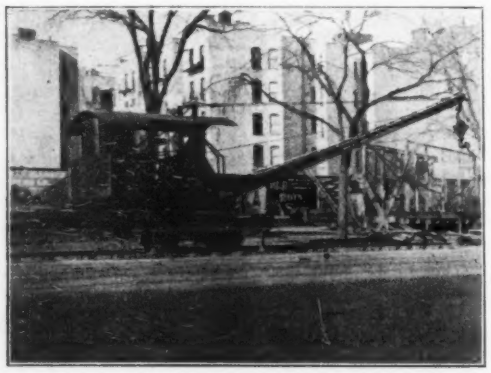


Fig. 100. View of Locomotive Crane Used in Handling Excavated Material on Section VIII.

sand and gravel, and on the Rodgers' section was almost entirely sand, in many cases of a first-class building quality. About the only factor to which the contractor had to give any particular attention was the seepage. Along the whole section the street surface is only about 20 ft. above tide-water, and the ground-water level was from 2 to 5 ft. above subgrade. The seepage, however, was never so great as to cause any difficulty in handling the water by pumping. The greatest trouble was the absolute necessity of keeping the water out when the excavation was once opened, for when the sand was wet it would run under the sheeting, and would cause settlement, unless constant attention was given to the pumps. At one point, however, the Sewer Department had some very heavy work to handle, as has been already described in a preceding article. Some difficult work was experienced at the location of the three northern stations, on account of the small head-room, where it was necessary to make an entire rearrangement of the multitude of ducts, pipes and the yokes of the street railway.

METHODS OF WORK.—The method of work adopted by the contractors of Section VIII. was to open a single wide trench to subgrade, sheet and brace the sidewalls and erect a steel and concrete structure within this trench. Practically, the only variation of methods of work adopted at different points came from the employment of different machines for handling the earth, which was excavated from the trench. There being no street car tracks over the line, and only one side of the street being occupied, the work was practically unobstructed, except at street crossings, where temporary bridges of simple form and construction served to carry the street traffic; and over the widened trench at the stations, and also at the turnout approach at the 135th St. station. At these points the tracks were held up on piles driven in rows of 10-ft. spacing on either side of the tracks, and doubly capped with steel or timber beams hung from the caps, and supporting the yokes of the trolley.

On the section from 110th to 116th St., the excavated material was all handled by a locomotive crane, which traveled on a track parallel to and alongside the trench. A view of this crane on the work is shown by Fig. 100. This crane was built by the Industrial Works, of Bay City, Mich. Its body was made up of 15-in. I-beams decked over with steel plate and carried on four wheels. On top of this body were carried the boiler engine and other machinery. The boiler was vertical, 42 ins. in diameter and 9 ft. high, and connected with it were a coal bunker and water tank. The engine was of the double-cylinder, reversible type, with 8 × 10-in. cylinders. Flexible wire rope was used for hoisting. The capacity of the crane, with a 25-ft. radius jib, as used on the work, was 5 tons. The crane complete weighed 33 tons. For the portion of the work on which this crane was used it proved to be a most economical and convenient device. The jib commanded the entire trench and hoisted the skips and dumped them into wagons.

For the portion of the work from 116th to 135th st., Mr. John C. Rodgers, employed several machines for handling the material, one being a double cableway, another being a telpherage cableway, and a third being a single rope cableway. The double cableway used was one built by the Rawson & Morrison Mfg. Co., of Boston, Mass. Fig. 101 is a general view of this cableway at work on the line, and Fig. 102 is a drawing illustrating its construction. In this cableway the towers were like those of ordinary cableways except that they were made wide enough to carry two parallel cables spaced 12½ ft. apart, each of which could be operated independently of the other. The towers were 35 ft. high, and were mounted on wheels to permit the cableway to be moved ahead as the work advanced. They were spaced 370 ft. apart, and the main cables were carried over them and anchored to piles driven into the ground at the rear. The main cables were 1½-in. wire ropes and the hoisting cables, carriages, etc., were designed for loads of 3 tons. The hoisting engines were carried on the head tower, as shown by Fig. 102. In operation the skips were lifted from the trench and dumped into elevated hopper chutes underneath which wagons were driven to remove the spoil. The steam plant for this cableway consisted of two locomotive boilers, located on the ground near the head tower. The capacity of this double-cableway plant, according to the builders, was 150 to 200 loads per working day of eight hours; but it never attained this capacity on the work owing to circumstances which prevented the development of its full efficiency, and also because the wheels of the towers were only 26 ft. apart, while the trench was 28 ft. wide, and, therefore, the towers could be moved ahead only after dismantling the cableway. After opening up a single stretch of trench, the double cableway was discarded by the contractors. The same fate was suffered by the telpherage cableway designed by Mr. F. W. Brother, used for a time between 123d and 125th

Fig. 101. View of Double Cableway Used in Handling Excavated Material on Section VIII.

streets. This device proved more successful on a succeeding section of the subway, however, and it will be described in more detail when the work of that section comes up for consideration in a future article. The third form of cableway used was the familiar Carson-Lidgerwood cableway, and it proved to be a very satisfactory and economical machine.

The erection of the subway structure after the trench had been opened was all straightforward work. It proceeded as follows: On the bottom of the trench a layer of concrete 1 ft. thick was laid and waterproofed on top. Next a layer of concrete was laid on top of this waterproofing to form the floor of the subway, and in it at the proper points were set the column footing stones. Next a 4-in. brick wall was built close to each side of the trench and waterproofed inside. The two sidewall columns and the center column were then erected and connected by roof beams to form bents setting between the brick sidewalls and on the concrete floor. The sidewall concrete jack arches were then molded between the sidewall columns and the roof arches built on centers in the usual manner. The backfilling of the trench and the restoration of the street pavement completed the subway structure.

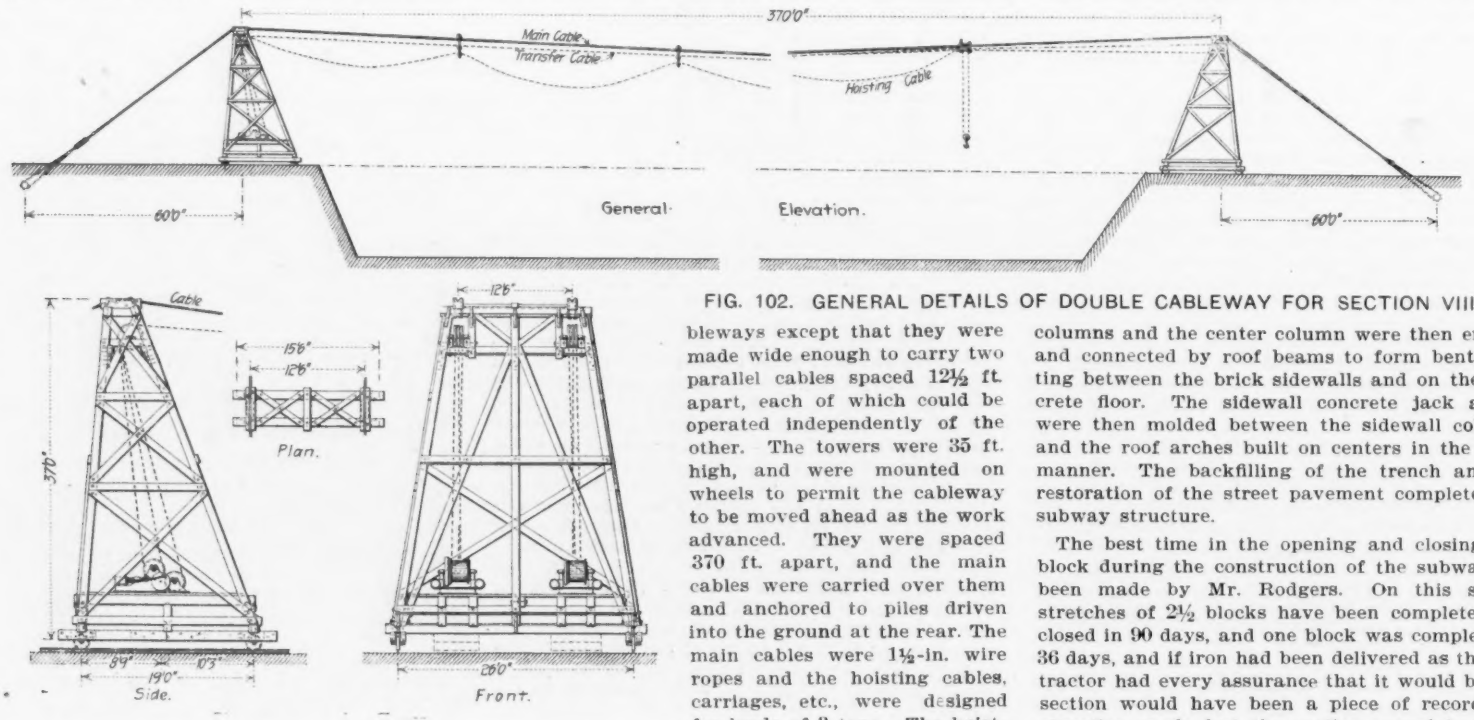


FIG. 102. GENERAL DETAILS OF DOUBLE CABLEWAY FOR SECTION VIII.

The best time in the opening and closing of a block during the construction of the subway has been made by Mr. Rodgers. On this section stretches of 2½ blocks have been completed and closed in 90 days, and one block was completed in 36 days, and if iron had been delivered as the contractor had every assurance that it would be, this section would have been a piece of record construction work, but the section record has been spoiled by the fact that the iron for the stations has not yet been delivered, which has been the cause of considerable annoyance to the engineers, contractors and owners of property adjacent to the subway.

The work of this section was carried out under the direction of Mr. Beverly R. Value, Engineer of the Rapid Transit Commission. Mr. W. J. Rodgers was in charge for the contractor, with Mr. F. W. Allen as Engineer.

EXPERIENCES WITH CAST-IRON COLUMNS IN TWO ENGLISH SPINNING MILL FIRES.

The complete destruction by fire of two English spinning mills is described in the November report of the Boston Manufacturers' Mutual Fire Insurance Co. One of the mills destroyed was located at Stockport, England, and its destruction was made horrible by the death by fire of nine persons and the injury of a large number of others. The other mill was located at Patricroft, near Manchester, and only one person was injured, but the destruction of the property was complete. The report on these fires was based on examinations and inquiries made by an expert, and is in full as follows:

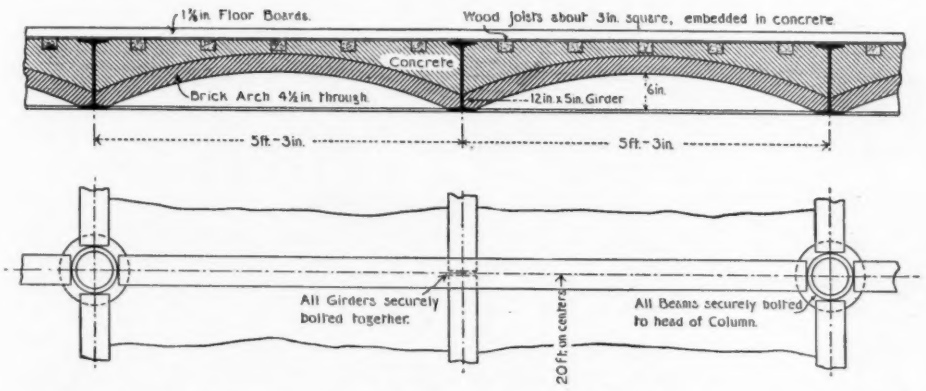


FIG. 1. DETAILS OF FIREPROOF FLOOR CONSTRUCTION OF SPINNING MILL AT STOCKPORT, ENGLAND.

STOCKPORT FIRE.—The spinning company to which this mill belonged is one of the most substantial and best-paying concerns in the country. Mill No. 1, being the one destroyed, was five stories including basement, which was used as a cop-conditioning cellar. The first floor was used for carding; the second, third and fourth floors for mule spinning. The spinning mules were placed withways on all the floors.

The floor of the basement is probably of brick, always soaked in water; the card-room floor was of brick arches, concrete, and flags; the spinning rooms were brick arches and concrete, made out of cement and coke breeze, with wood joists embedded in the concrete and finished on the top with 1⅛-in. butt-jointed spruce boards, which is the common flooring board used in this country. The principal girders were of wrought iron or steel, with transverse wrought-iron or steel girders resting on the bottom flange of the main girder. The floor was, therefore, solid right through, with only the bottom flanges of the girders exposed. The columns were of cast iron, left bare. Attached to No. 1 mill a five-storied extension had been built, and was only finished this year. There are five floors, each on a level with the floors of the No. 1 mill, and the processes of manufacture in the rooms correspond.

The former windows at the end of No. 1 mill had been cut down to the floor level, so that each room of No. 19 was fully open to each room of the No. 1 mill. The construction of the floors of No. 19 was of the modern so-called "fireproof" type, now general in this country. The workmanship of the floors was first-class, and there were no holes through them. The sketches herewith (Fig. 1) show the construction of both types of floors; that of the new portion (No. 19) has all the steel work embedded in concrete and plaster, excepting the very bottom of the flanges of the principal girders. The columns are cast iron, and are exposed. The roof all through was flat and solid, of incombustible material, and corresponded with the construction of the floors.

There were two incombustible staircases of brick and stone, for the use of the operatives, and about the center of no. 1 mill there is a hoist tower communicating with all the five stories, up and down which yarn was taken into the various rooms, the doorway in each room being protected with a single wrought-iron door, running on a horizontal overhead rail, with grooved pulleys, and which were not automatic-closing.

After the fire the hoist door opposite where the fire started was found wide open and was evidently so when the fire broke out, as the door was pinned against the wall by the fallen brickwork from above, and could not have been moved in the meantime. Whether the iron hoist doors in the rooms above and below were open we do not know. The common practice in our factories where this system of hoist arrangement is adopted is to leave the iron door open, and use a vertical sliding lattice door to prevent people falling down the hoist hole, the iron doors being supposed to be closed at night or in time of fire. The mule in which the fire broke out had been stopped with the carriage under the creels, and so had all the other mules in the room, although it is common knowledge that in a mule-room fire the carriage ought to be stopped out.

We are at a large loss to understand how it comes about that a mill of this construction, with a staircase at each end, should be so enveloped in smoke and flame that the limited number of operatives in the rooms above could not get out of the place by one of the two staircases, which were at each end of the mill. The story told to us by the on-lookers at the fire was to the effect that the wind was from the river side; that the windows on that side of the mill must have been broken; and that the smoke and heat were blown through into the staircases, enveloping them with so much dense black smoke that the workers were not able to face it and get down the saircases, and had to be rescued through the windows, with the disastrous result which you can gather from the newspapers we are sending.

Another very pecular feature is the tremendous speed with which the whole of the rooms in the mill were charged with this dense black, penetrating smoke, which prevented the operatives seeing their way, and prevented them from breathing.

When the fire brigade got to the mill they did nothing in the way of putting water upon it or trying to extinguish the fire; their sole effort was directed for quite a considerable time to saving life. The firm have no automatic sprinklers in their mills, but were in treaty for an installation. As far as we can gather, the appliances and means of extinguishing a fire were of the most primitive description. There was in Mersey St. a comparatively small main of probably 3 or 4 ins. diameter, and attached to it was a hydrant running up the staircase at the yard end of the mill, upon each floor being a hydrant valve, with hose pipe. In the yard was a hydrant from a small boiler pump. We do not know the exact size of the main in Mersey St., but we judge it can only be very small, for the reason that to get a 6-in. pipe for the proposed installation it was necessary to go back 250 yds. from the mill to the nearest 6-in. main, there being a 10-in. main in another direction, also about 250 yds. away. The water pressure is normally 80 lbs.

It has come to be recognized amongst our firemen, and intelligent people who are interested in buildings of this class, that they are extremely dangerous to deal with in certain stages of a fire, and probably before long some better system will be evolved, either in the way of construction or of extinguishment of fire.

We have also received notice of a fire which took place on Nov. 18, 1902, at Patricroft, a village about six miles from Manchester, England. This mill was of similar fireproof construction. The hands were just returning to work and, therefore, few persons were in the building. A workman who was in one of the rooms was rescued and taken to the hospital. By 3 o'clock the building was gutted. The mill employs 400 hands, chiefly spinners.

FIG. 2. VIEW SHOWING WRECK BY FIRE OF SPINNING MILL AT STOCKPORT, ENGLAND.

The fire swept all before it; floor after floor fell with a crash. It began on the third floor at one end of the building, and was caused in precisely the same way as that at the Vernon Mills, Stockport. The spread of the fire was so rapid that some few of the employees had difficulty in getting out of the building. Fortunately, iron escapes were fixed outside of the walls, and these were used by the work people in reaching the street. It is impossible at the present moment to say what the damage amounts to, but it can hardly be less than £100,000. At the time of the outbreak of this fire the flat roof of this mill was covered with about 12 ins. of water, so that this mass of water was delivered into the mill, but caused no apparent check upon the fire. It is not an uncommon fact in English mills to make the roof a sort of reservoir.

Both these fires are assumed to have originated in friction in the head stock of the mule. From the several accounts given in the press, and from the account of my correspondent, it would appear that the collapse of these two buildings and the nearly complete destruction of both mills may be attributed almost wholly to the BREAKING OF THE CAST-IRON POSTS, and not to the yielding of the floors or roof, in either instance, until the supports had given way.

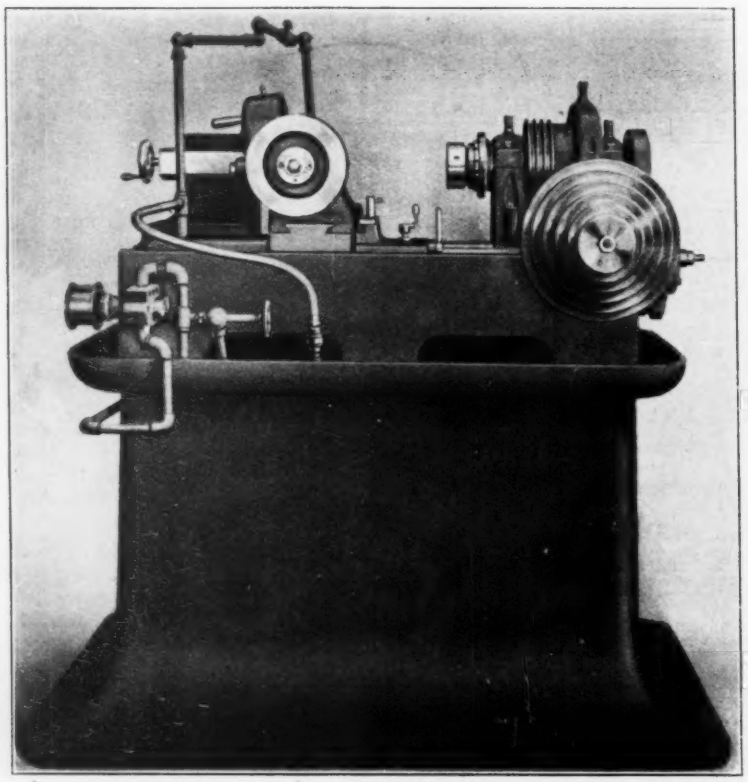
THE MILLING-CUTTER APPLIED TO THE PRODUCTION OF SCREW-THREADS.

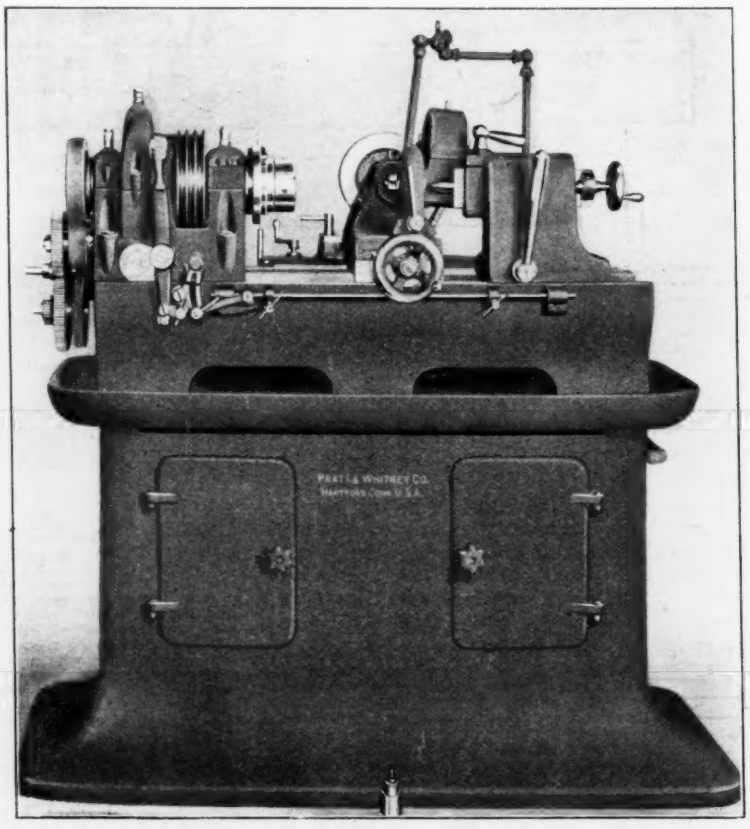
To produce ordinary screw-threads two methods have been available in the past; first, cutting the thread in the lathe, and, second, producing the thread by the use of threading-dies or taps. Lathe-cutting is the more general of the two methods, and may be called the standard method of producing threads. It involves rotating the piece to be worked, applying a cutting tool mounted on a firm support, and moving the tool at a uniform rate in a direction parallel to the axis of the rotating piece; the motion of the cutting tool relative to the work traces a helical line on the latter, and if the tool is provided with a suitably shaped cutting edge it may be manipulated so as to form the desired thread.

There are a number of features incident to this method which make it less efficient and less economical than other processes of the modern machine shop. In recent years, while shop work has been cheapened and "modernized" everywhere and in every detail, the high cost of screw-cutting has been felt increasingly to be out of harmony with the results reached in other work. The relatively high cost is aggravated by another feature of the process of cutting screw-threads in the lathe: the low limit of accuracy which is attainable (except at disproportionately high cost).

A new method of screw-cutting has been worked out recently and has been made generally available by the construction of a special machine for carrying it out. The new process aims to obviate some of the disadvantages of the lathe-process, by cheapening the work and making it suited for realizing the considerable saving due to production in quantity—a saving impossible with lathe-cutting. It is thought that at the same time an increased accuracy is attained, in fact, that the machine will regularly produce screws meeting all

requirements except for high-precision instruments. The essential new feature of the process is the use of a milling-cutter for forming the thread, in place of the ordinary lathe-tool; the process may be said to stand in the same relation to lathe-cutting as milling with formed cutters does to forming with the shaper. The new machine, built by the Pratt & Whitney Co., of Hartford, Conn., is decidedly interesting, and merits study. Some samples of work produced by the machine were shown us at the office of the company, 136 Liberty St., New York, and if their accuracy and their cheapness compares with their finished appearance, they speak well for the performance of the machine.





FIGS. 1 AND 2. FRONT AND REAR VIEW OF 6 x 14-IN. THREAD-MILLING MACHINE.
Built by Pratt & Whitney Co., Hartford, Conn.

The Pratt & Whitney "Thread-Milling" machine, views of which are shown in the accompanying Figs. 1 and 2, is in arrangement a lathe fitted with a milling-head on the traveling carriage. This head contains an arbor carrying a milling cutter driven by independent drive from the countershaft. As in the ordinary engine lathe, the headstock spindle supports the work and rotates it, and the carriage with the cutter is moved along the work by a lead screw driven through change gearing from the spindle. The action of the machine, while similar to, is essentially different from the action of a lathe in cutting threads. In the lathe the rotation of the work by means of the spindle effects the cutting, since it forces the work past the cutting edge of the tool. In the thread-milling machine, the cutting is effected by the rotation of the milling-cutter, whose radial cutting edges shape the desired thread; the rotation of the work by the headstock spindle serves merely to feed the work to the cutter, in conjunction with the travel of the carriage. Practical shopmen will realize that this difference of action makes it possible to secure considerably greater accuracy of work with the new machine. At the same time another, and a far more important, result is secured: the skilled lathe operator is replaced by a comparatively unskilled man operating the thread-milling machine, so that the cost of labor in cutting threads is reduced. A further reduction in labor cost results from the less time required for cutting screw-threads on the new machine as against the lathe; this latter reduction, of course, becomes effective principally where much duplicate work is to be done.

The thread-milling machine, though built on the lines of a lathe, necessarily was designed with radically different proportions of parts from those customary for lathes. It is therefore a new machine in every respect. This is shown to some extent by our views, Figs. 1 and 2, already referred to; however, a large part of the new design lies in the proportioning of the details, and this of course cannot be shown in the views. The general construction of the machine may be described as follows:

The bed is similar to a lathe bed; it has a single V-slide at the rear and a flat slide at the front. The headstock and tailstock rest on these slides, and are clamped in the usual way. The carriage, however, travels on flat slides at front and rear, and is gibbed in a narrow angular slide at the rear and a flat gib, underneath, at the front of the machine. The lead screw, for moving the carriage, is at the rear of the machine, located within the angular carriage slide; this brings the pull of the carriage on the lead screw about in line with the resisting pressure of the work on the cutter.

On the carriage is a cross slide, and this carries

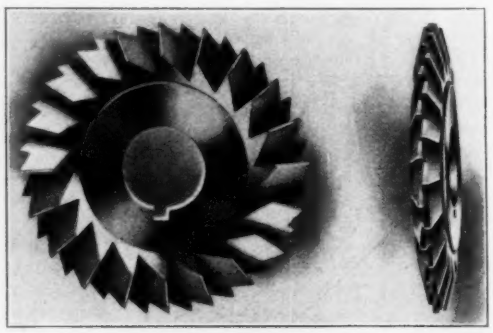


Fig. 3. Milling-Cutter Used On Thread-Milling Machine.

a tilting head for the milling-cutter arbor. The center of this arbor is in the same horizontal plane as the center of the headstock, and the trunnions of the tilting head are in the same vertical plane as the center of the milling-cutter. The tilting of the head enables the cutter to be set for the proper angle of the thread to be cut, and the arrangement described ensures that the acting face of the cutter is always level with the center line of the work. A graduation on the tilting head is provided for this setting of the cutter. The depth of the cut is regulated by a screw and hand wheel actuating the cross slide, and may be accurately adjusted by a micrometer head.

For driving the milling-cutter the cutter arbor is fitted with a multiple-grooved driving wheel; six independent round belts run in these grooves, passing around a drum on the countershaft. The provision of six independent belts has the object of avoiding damage to the work when one of the belts breaks; the remaining belts are then ample to drive the cutter, while if a single belt were provided a similar accident would almost certainly ruin work or cutter or both.

The carriage lacks the apron of the ordinary lathe carriage, since only a single means of traveling—the lead screw—is provided. The nut which engages the lead screw is not fixed in the carriage, but may be rotated by hand through a small crank lever; this provides for traveling the carriage, independently of the power feed. A separate lever locks this nut for regular operation. At the front of the carriage, in place of the feed spindle of the ordinary lathe, is a longitudinal rod carrying stop-dogs; the rod is connected to mechanism for throwing out the feed, i. e., both the rotation of the main spindle and the travel of the carriage. A hand lever (seen in front of the headstock in Fig. 1) enables this stop-mechanism to be operated by hand.

The headstock, in combination with the lead screw, forms the feed mechanism, as already explained. The headstock is quite simple in construction, the only novelty being the use of a double spindle. A hollow outer driving spindle encloses an inner spindle carrying the collets or face plate for holding the work; a notched index ring on the inner spindle, engaged by a pawl on the outer spindle, locks the two together. The purpose of this arrangement is to set the machine for multiple threads or for spiral gearing; after one thread has been cut the pawl is released from the index ring, and the inner spindle is turned through the appropriate part of a revolution to bring the work into position for the next thread, when the index ring is again locked by the pawl. By using an index ring with a suitable number of notches any desired division may be obtained.

It will be seen that the headstock carries a triple-grooved pulley. This is for driving the return of the carriage after completing a cut; a higher speed of return is thus obtained than cutting speed, without changing the feed gearing. The feed is driven from the grooved cone pulley shown at the rear of the headstock, which is belted to the countershaft by a round belt. The spindle of this pulley is normally geared to the headstock spindle, and the lead screw is driven from the latter by a train of change gearing on the end of the headstock. For screws of large pitch, however, and for spiral gearing, it is better to drive the lead screw directly and gear from this to the headstock spindle; simple means are provided for changing the connection of the driving pulley in this manner.

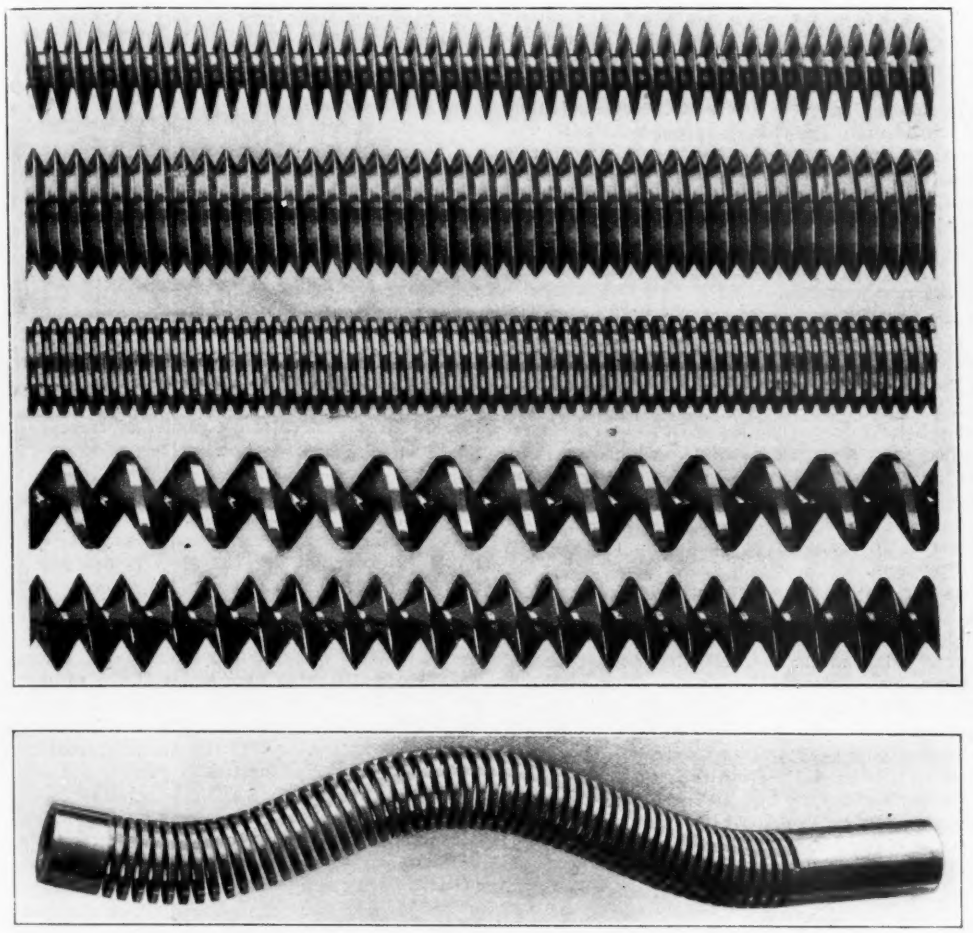


FIG. 4. SPECIMENS OF WORK DONE ON THREAD-MILLING MACHINE.

A special form of milling-cutter was designed for use in the thread-milling machine. Its peculiarity is that the cutting teeth are staggered, alternate teeth cutting on alternate sides. Novel means are employed for producing these staggered teeth, as will be seen by reference to Fig. 3, which shows two views of such a cutter. The outline of the cutter, i. e., of its cutting edges, is given by turning the cutter to the desired shape. This is intersected by a series of oblique notches on each side, but the notches on the two sides are staggered with respect to each other, as is shown in the edgewise view of the cutter, in Fig. 3. This style of cutter is used for general work on the thread-milling machine; for threads with a sharp angle at the root, and for spiral gear teeth, milling-cutters of the regular form are employed.

Special means are employed for holding the work on the headstock spindle. For work less than 2 ins. in diameter, split collets of proper size are used, and these are fitted with a clamping ring for gripping the work. When the diameter of the work exceeds 2 ins. (the machine as built at present will take work up to 6 ins. in diameter) a solid collet fitted with live center is used in place of the regular split collets. A removable face plate surrounding the live center is furnished, and a movable segment of this face plate may be set to clamp the tail of the lathe-dog for holding the work without backlash.

Some specimens of the work produced by the thread-milling machine are shown in Fig. 4. Screws, worms and spiral gears are cut with equal facility and accuracy. One of the pieces shown in Fig. 4 is especially worthy of note: a helical spring cut from tubular stock, with the thread or slot not extending to the ends of the piece, so that the spring is left with full, square ends. While it is not probable that such springs will be used very extensively, the specimen shows what the machine will do. In connection with this piece it should be noted that the machine is normally set to cut toward the headstock, which gives a right-hand thread. By inserting an idler in the change gearing the machine may, however, be used to cut left-hand threads, working toward the tailstock. For such work, and also for long and thin right-hand screws, a back rest is provided, which is a frame, mounted on the bed, adapted to hold a bushing of proper bore to fit the work.

The thread-milling machine is built in two sizes, differing only in length of bed. The maximum diameter of work that either machine will take is 6 ins.; the smaller machine will cut a thread 14 ins. long, the larger machine a thread 80 ins. long. The lead screw regularly provided with the machine has 6 threads per inch, and change gears are furnished for cutting threads from 20 per inch to 4-in. pitch. A metric lead screw, having a thread of 4-mm. pitch, may be furnished, however, and "translating" change gears may be had for cutting English threads with the metric lead screw or metric threads with the English lead screw. For spiral gear work, and for coarse pitch screws, special coarse pitch lead screws are recommended by the makers.

The builders of this machine, the Pratt & Whitney Co., of Hartford, Conn., have issued a neat descriptive pamphlet about the machine. This pamphlet was reviewed in our issue of Dec. 18, under the heading "Trade Publications." A slight error in that review may be corrected here. We stated that a special cutter-grinder, built by the same makers, was required to grind the staggered teeth milling-cutters used on the thread-milling machine. This is not the case, since the cutters may be ground on any cutter-grinder (or even by hand); however, the special grinder referred to does the grinding automatically and with much greater facility and dispatch, and therefore is economical wherever more than a small amount of such grinding is to be done.

NOTES ON THE EVOLUTION OF THE DROP HAMMER FOR DIE FORGING.

By E. W. Merrill, Jr.*

Few tools in the modern manufacturing plant have had a greater part in making possible the rapid and cheap production of metal articles than the drop hammer.

Probably the first form of hammer used in connection with die forgings was the "Oliver," which was operated by foot power. This type of hammer had about the capacity of a heavy hand sledge, but as compared with this latter it was a convenient device for making the hammer strike the work always in the same place, and also avoiding the necessity of an extra man as helper. It was confined, however, to very small work.

For larger forgings the simplest and probably the oldest form of drop hammer was the "kick stamp," which consists of a base, two uprights fastened to the base, and a ram or hammer fitted between the two uprights. The hammer is lifted by means of a belt with one end fastened to the hammer and the other end passing over a continuously revolving pulley, with a suitable hand rope attached to the loose end of the strap. When hammers of over 800 lbs. are used with this lift, the operator's hands are assisted by the feet engaging a stirrup at the end of the hand rope. This style of drop hammer is still very extensively used. Within the past year the writer visited a forge shop in the central part of England, where the eight or ten drop hammers in use were all of this type and were making forgings to compete in the open market. It was the intention, however, to change to the more modern lift as soon as practicable.

About 35 years ago, the Hope Iron Foundry of Providence, R. I., manufactured and put on the market a friction lift drop hammer, known as the Golding & Cheeney patent. This lifter was operated entirely by belt power and consisted of two smooth friction rolls, continuously revolving in opposite directions. Between these rolls was placed a board, the lower end of which was securely fastened to the hammer. The shaft bearings of one of these rolls were fixed. The bearings of the other roll were so arranged that they could be moved forward or back when desired, by the operator. The forward movement pinched the board and created friction enough to raise the hammer; and the backward movement of the roll released the board, thus giving the hammer a free fall.

A few years after the Hope works commenced manufacturing these hammers, Charles Merrill & Sons, of Brooklyn, N. Y., acquired a right to manufacture under the Golding & Cheeney patent and at the same time secured the Waters' patent, which dispensed with gearing for driving the two friction rolls and substituted a drive by means of one straight and one cross belt.

The method of lifting the hammer by pinching a hardwood board between two revolving rolls, as covered by the Golding & Cheeney and Waters' patents, stands to-day as the best practice in friction lift drop hammers.

Quite a number of devices have recently been applied by several drop hammer manufacturers to improve the operation of friction board lifts. Two or three well-known manufacturers have recently devised methods for securing a slow and easy lift of the eccentric rod. Some users of drop hammers prefer this slower and, therefore, quiet method of lifting the rod, to the more rapid and noisy system of rod lift. The rapid lifting of the rod, however, owing to the momentum, must necessarily open the friction rolls wider, thereby allowing a greater scope for unevenness of boards, and also avoiding the necessity of frequent rebabbitting of the roll-shaft bearings.

Wishing to dispense with the bent eccentric rod, which, when the pin and bearings become worn, allows one eccentric to fall before the other, thereby reducing the friction upon the rolls; and

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also desiring to make a lifter which could be placed over a drop hammer of any width, the writer, some six years ago, designed a friction board lifter embodying these improvements. These results were obtained by substituting in place of the two eccentrics a single cam shaft, connected at one end to a short lever, a slight movement of which presses the movable friction roll forward to grip the lifting board.

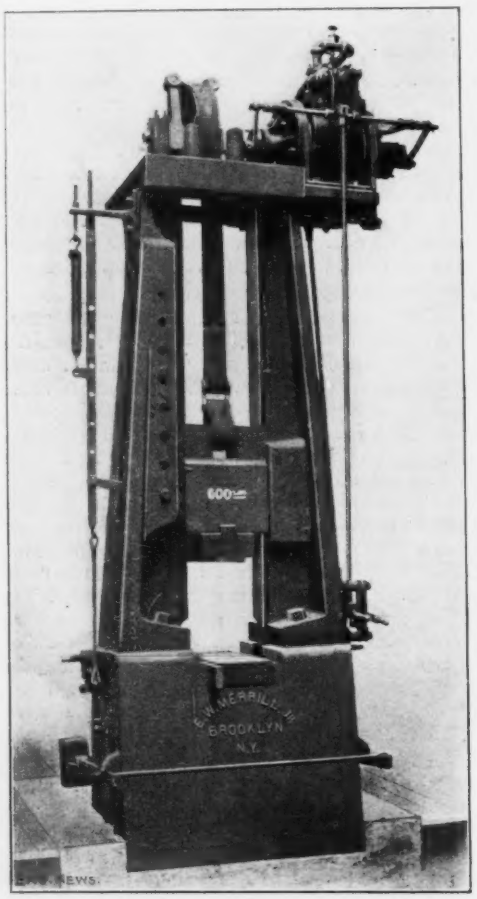

Fig. 1. The Brett Drop Hammer with Direct-Steam Lift.

Another form of power hammer quite largely used by silversmiths and sheet metal workers is the one known as the "crank lift." When a rapid and elastic blow is not necessary, this device when not overloaded has given excellent satisfaction, owing to its simplicity. Hammers of this type have been on the market many years and have many warm advocates. This style has, however, its disadvantages, among which is the necessity of using a heavier ram than would be required with any other gravity fall hammer, as there is not a free fall. The hammer, therefore, consumes more power for a given work. However, it can successfully raise heavier weights than are practicable with the friction lift.

The above mentioned power drop hammers, in connection with the milling machine, have made possible the cheap and rapid production of small forgings, and have had a large part in building up the interchangeable system of manufacturing, of which the sewing machine and firearms industries are perhaps the best known examples.

Within the past few years there has been an increasing demand for larger die-forgings than could be successfully made by the drop hammers mentioned above. This requirement for larger forgings has been the means of developing the direct acting steam drop hammer for die work. This hammer consists of the usual arrangement of anvil or base and guides, for the hammer or ram, with a vertical steam cylinder attached to the top of the guides. The ram is connected by a rod to the piston in the cylinder.

The disadvantages experienced with this type of hammer are that, by reason of the piston rod and piston being directly connected with the hammer, they necessarily receive a shock at every blow, which has a tendency to crystallize the piston rod, particularly as the blow is often a little to one side. Further, the stuffing box, being directly over the ram and dies, there is liability of water dripping upon the dies.

The latest notable achievement in drop hammer improvement is the semi-rotary steam lifter invented by Mr. E. S. Brett, of Coventry, England. Mr. Brett is the owner of a large drop forge works in Coventry, and he designed this improvement and put it into use in his own shops six or seven years ago. Its success there was such that a company was organized to manufacture these semi-rotary lifts for drop hammers and place them on the market, and they have since then been rapidly introduced in English and colonial shops as well as on the Continent.

When designing these lifters Mr. Brett undoubtedly had in mind the trouble experienced with uneven and warped lifting boards, together with the limitation in size of hammer which can be successfully raised by the friction system. He also desired to obviate the trouble experienced with the direct acting steam lift, from the crystalization of piston rod, and the drip of water directly over the ram and dies.

In the Brett lifter in place of the friction boards the ram is lifted by a strong cotton belt, in the smaller sizes up to about 1,200 lbs. weight of ram; and for the larger sizes, by stout manila ropes, several being placed side by side. The other end of the belt or ropes is fastened to an arm attached to the piston shaft, which arm is given an oscillating motion by the action of the steam on a radial piston inside the cylinder. At the head of the guides is an idler pulley, over which the belt runs in passing from the ram to the lifter arm.

These lifters can be constructed to successfully raise hammers of almost any desired weight. Soft steel locomotive pistons, weighing 240 lbs. each, are now being made in dies with one of these hammers.

The sectional drawing (Fig. 3) will make clear the operation of the lifter. With the parts as shown in Fig. 3 the hammer would be down and at rest.

In order to raise the hammer, the steam enters the port A, presses against the piston wing B, and forces the piston, say, to the position E. When the piston reaches the position E the live steam is cut off and the steam in the cylinder returns through the port A and out to the exhaust, allowing the piston E to return to the starting point B.

The lifting arm F is in one piece with the piston shaft C; consequently when the piston B takes the position at E, the lifting arm F will take the position K. The lifting strap H is fastened to the two arms by the cross-bar G; consequently when F takes the position K, the hammer, which is fastened to the strap, will be lifted a certain distance, this distance being varied by the position of the operating levers.

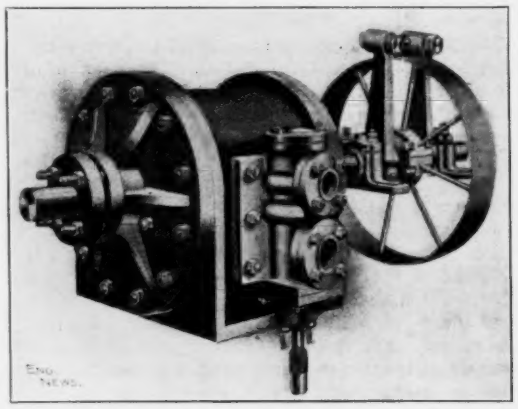

Fig. 2. Steam Lift for Brett Drop Hammer.

D is the division block and L the relief and safety vent.

It will be noticed that the loose pulley J is not fastened to the shaft, and it therefore serves merely as an idler to change the rotary movement of the arm to a vertical and central lift.

The hammer can be made to deliver one blow or a series of equal blows automatically, or to give variable light and heavy blows.

When working automatically and wishing to alter the distance of fall of the ram, the only change necessary is to raise or lower the catch-up latch and pin on the left side of the drop and raise or lower one of the levers at the right side of the drop which controls the position of the automatic tripping. Changing the automatic trip lever to any desired position can be accomplished in a few seconds while the hammer is in operation

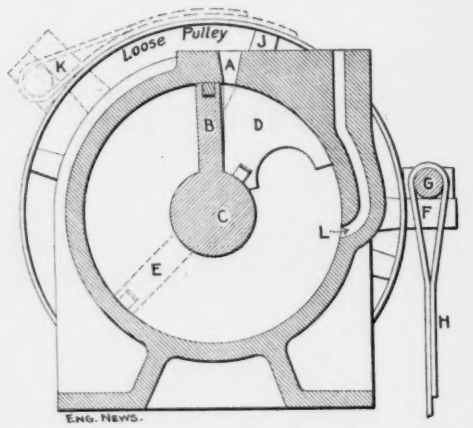

Fig. 3. Section of Steam Cylinder of Direct-Steam Lift.

or at rest. The lever is held in position by a series of notches cut in a quadrant.

To deliver variable light and heavy blows, the lever at the right side of drop is operated the same as on an ordinary steam hammer.

This hammer will operate as fast as is consistent with the successful manipulation of the stock in the dies. A rate of fifty to seventy blows per minute are ordinarily obtained. At the same time the blows are of that elastic nature best suited for die forging. There are no rods or slides for the hammer to strike, as the tripping is accomplished by the semi-rotating shaft and without jar or perceptible wear.

The steam having free passage to the exhaust the hammer consequently has a perfectly free fall.

When setting up this drop hammer the only connection necessary is a pipe to convey the steam or compressed air, consequently it can be placed in any convenient location in a factory, irrespective of line shafting. Wherever, by reason of the exclusive use of electric drive, or of water power, live steam is not available for drop hammers, compressed air can be used in the same manner as steam, and without changing any of the parts.

The important items in the economy of power by this system are in avoiding the necessity of driving heavy line shafting and slipping belts, and also in not expending power while the hammers are not actually operating. The cost of the heavy engines, shafting, hangers and long belts necessary for the usual method of drop hammer drive is dispensed with in this system, consequently the initial cost of a plant is very materially reduced.

A valuable feature of this lift is the practicability of placing it over any style or size drop hammer already in use. Almost any kind of overhead support or framework will answer, as there is no tendency of the supporting parts to rack or sway sidewise. The only strain is a downward pressure equal to the force necessary to raise the hammer.

The lifter can be placed upon the floor above the drop hammer, or on the floor behind the base, with an extra pulley to guide the strap or rope, and it can also be placed at right angles to the slides and over the hammer, if lack of space will not permit placing otherwise.

As stated above, these hammers have come into very extensive use during the past few years in English forge shops, and notably in locomotive shops, on account of the large size of the forgings which are now being made on dies. On a recent visit to England the writer found these hammers in use in every locomotive works in England and Scotland, the largest number being at the famous Crewe shops of the London & Northwestern Ry., where no less than eighteen are in use.